INSTRUCTION BOOK

for

MULTIPLEXER GROUP
AN/TCA-1

PREPARED FOR

THE SIGNAL CORPS

ON ORDER NO. 4663-PHILA-52

30 JUNE 1955

FORWARD COMMENTS ON THIS PUBLICATION DIRECTLY TO:

Commanding Officer
The Signal Corps Publications Agency
Fort Monmouth, New Jersey
ATTN: Standards Division

WARNING

Be sure that the filter located on the filament supply is kept clean at all times. Always cap unused receptacles on Voltage Regulator CN–236/G.

DON'T TAKE CHANCES!

EXTREMELY DANGEROUS VOLTAGES EXIST IN THE FOLLOWING UNITS:

Oscilloscope OS-25/G

Cathode-ray tube	1,080 volts
1,800-volt rectifier	1,980 volts
1,500-volt rectifier	1,980 volts

INSTRUCTION BOOK

for

MULTIPLEXER GROUP

AN/TCA-1

PREPARED FOR
THE SIGNAL CORPS
ON ORDER NO. 4663-PHILA-52

30 JUNE 1955

INSTRUCTION BOOK
SIGNAL CORPS

ORDER NUMBER
4663-PHILA-52

30 JUNE 1955

MULTIPLEXER GROUP AN/TCA–1

CHAPTER 1. INTRODUCTION *Paragraph* *Page*

Section I. General 1, 2 1
II. Description and data 3-32 2
III. Basic principles 33-37 25
IV. Functional circuits of Multiplexer Group AN/TCA–1 .... 38-46 28

CHAPTER 2. INSTALLATION

Section I. Service upon receipt of Multiplexer Group AN/TCA–1 .... 47-52 32
II. Installation and adjustment procedures 53-57 40

CHAPTER 3. OPERATION

Section I. Controls and instruments 58-68 58
II. Operation under usual conditions 69-75 67
III. Operation under unusual conditions 76-79 71

CHAPTER 4. ORGANIZATIONAL MAINTENANCE

Section I. Organizational tools and equipment 80-82 73
II. Preventive maintenance 83-86 74
III. Lubrication and weatherproofing 87-89 78
IV. Trouble shooting at organizational maintenance level 90-99 78

CHAPTER 5. AUXILIARY EQUIPMENT 100-108 103

CHAPTER 6. THEORY OF OPERATION

Section I. System theory 109-118 110
II. Theory of video restorer 119-133 116
III. Power supplies 134-136 145
IV. Test equipment 137-144 150

CHAPTER 7. FIELD MAINTENANCE

Section I. General trouble-shooting techniques 145-162 177
II. Trouble shooting the video restorer 163-169 183
III. Trouble shooting the modem 170-176 193
IV. Trouble shooting the delay line 177-180 201
V. Trouble shooting the mounting rack 181, 182 203
VI. Trouble shooting Multiplexer Subassembly MX–1442/TC 183-187 207
VII. Trouble shooting Power Supply PP–691/G 188-191 212

VIII. Trouble shooting Oscilloscope OS-25/G 192-197 215
IX. Trouble shooting Control Monitor C-1151/TC 198-201 234
X. Trouble shooting Audio Test Set TS-762/TC 202-207 237
XI. Trouble shooting Voltage Regulator CN-236/G 208-212 247
XII. Repairs 213,214 252
XIII. Alignment, adjustment and final testing 215-218 253

CHAPTER 8. SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Section I. Shipment and limited storage 219,220 266
II. Demolition of materiel to prevent enemy use 221,222 267
INDEX 269

LIST OF ILLUSTRATIONS

Fig. No.	*Title*	*Page*
1	Typical installation of Multiplexer Group AN/TCA-1	xii
2	Single hop tdm radio-relay system, block diagram	3
3	Multiple hop tdm radio-relay system, block diagram	4
4	Electrical Standardized Components Case CY-1280/U	10
5	Electrical Standardized Components Case CY-1280/U, covers removed	11
6	Multiplexer Group AN/TCA-1, multiplexer rack, front view	12
7	Multiplexer Group AN/TCA-1, multiplexer rack, rear view	13
8	Multiplexer rack, front view, 16 Modems MD-179/TC removed	14
9	Multiplexer subassembly, rear cover removed, showing location of remote keying units	15
10	Multiplexer Group AN/TCA-1, test rack, front view	16
11	Multiplexer Group AN/TCA-1, test rack, rear view	17
12	Accessories Case CY-1334/G	18
13	Voltage Regulator CN-236/G	20
14	Switch Box SA-357/G, front and rear views	21
15	Electrical Connector Assembly J-535/G	21
16	Spare Parts Case 1 and Case 2	22
17	Main power cables	23
18	Interconnecting power and signal cables	24
19	Principle of wave form reshaping	25
20	Simple time-division multiplex example	26
21	Eight-channel, time-division multiplex example	26
22	Principle of pulse-position-modulation	27
23	Principle of time-division multiplexing	27
24	Remote keying operation between multiplexer location and mobile unit, block diagram	30
25	Remote keying operation between two mobile units, block diagram	—
26	Typical packaging diagram for equipment rack crates	33
27	Typical packaging diagram for small crates	34
28	Multiplexer rack, rear view showing receptacles	35
29	Test rack, rear view showing receptacles	36
30	Switch box output receptacles	37
31	Interconnection diagram	38
32	Video restorer, front view	41
33	Video restorer blower fan	42
34	Filament supply, front view	43
35	Filament supply blower fan	43
36	Switch box, front view	44
37	Voltage regulator, front view	44
38	Power supply, front view	45
39	Oscilloscope, front view	45
40	Test set, front view	46
41	Location of modem 2W-4W switch	46
42	Mounting rack, rear view, binding post doors open	47
43	Control monitor, front view	49
44	Modem, front view	50
45	Oscilloscope with probe connected	50

LIST OF ILLUSTRATIONS (contd)

Fig. No.	*Title*	*Page*
46	Rear view of filament supply showing handles and mounting screws	56
47	Rear view of filament supply, rear cover removed, showing remote keying units inserted for remote keying operation	56
48	Telephone Modem MD–179/TC controls	60
49	Multiplexer Subassembly MX–1442/TC controls	62
50	Oscilloscope OS–25/G controls	63
51	Audio Test Set TS–762/TC controls	63
52	Control Monitor C–1151/TC controls	64
53	Power Supply PP–691/G controls	64
54	Voltage Regulator CN–236/G controls	65
55	Switch Box SA–357/G control	66
56	Operational switches (channels 1 and 2), block diagram	70
57	DA Form 11–238	75
58	DA Form 11–239	76
59	Input wave form, at E1, INPUT FROM EASTFACING REC	79
60	Output form, at E2, OUTPUT TO WESTFACING XMTR	79
61	Wave form at DEMTPX GATE test point E5	80
62	Wave form at BLANKING GATE test point E4 (channels 1 and 2 in D&I)	80
63	Wave form at MTPX GATE test point E6	81
64	Wave form at MODEM CHAN PULSES test point E3	81
65	Wave form at pin 8 (plate) of V1	83
66	Wave form at pin 5 (plate) of V2	83
67	Wave form at pin 7 (plate) of V3	83
68	Wave form at pin 5 (plate) of V4	83
69	Wave form at pin 6 (plate) of V5	84
70	Wave form at pin 8 (plate) of V6	84
71	Wave form at pin 5 (plate) of V7	84
72	Wave form at pin 7 (plate) of V8	84
73	Wave form at pin 5 (plate) of V9	85
74	Wave form at pin 6 (plate) of V10	85
75	Wave form at pin 6 (plate) of V11	85
76	Wave form at pin 1 (plate) of V12	85
77	Wave form at pin 3 (cathode) of V13 (channel 1 in D&I)	86
78	Wave form at pin 1 (plate) of V15A	86
79	Wave form at pin 6 (plate) of V16	86
80	Wave form at pin 5 (plate) of V19	86
81	Wave form at pin 8 (plate) of V20	87
82	Wave form at pin 8 (plate) of V21	87
83	Wave form at pin 8 (plate) of V22	87
84	Wave form at pin 5 (plate) of V23	87
85	Wave form at pin 5 (plate) of V24	88
86	Wave form at pin 5 (plate) of V26	88
87	Modem test points	88
88	Wave form at modem PPM test point	88
89	Wave form at pin 1 (plate) of V1A (modem)	89
90	Wave form at pin 6 (plate) of V1B (modem)	89
91	Wave form at pin 1 (plate) of V2 (modem)	89

LIST OF ILLUSTRATIONS (contd)

Fig. No.	*Title*	*Page*
92	Wave form at modem PWM test point J2 (modem)	90
93	Wave form at pin 1 (plate) of V3A (modem)	90
94	Wave form at pin 1 (plate) of V4A (modem)	90
95	Wave form at pin 6 (plate) of V4B (modem)	91
96	Oscilloscope test points	92
97	Video restorer, tube location diagram	96
98	Modem, tube location diagram	98
99	Voltage regulator, tube location diagram	98
100	Oscilloscope, bottom right section, tube location diagram	99
101	Oscilloscope, bottom left section, tube location diagram	99
102	Oscilloscope, bottom center section, tube location diagram	100
103	Audio set, tube location diagram	101
104	System audio levels, private operation	106
105	System audio levels, party-line operation	107
106	Multihop radio-relay link, block diagram	108
107	Multiplexer Group AN/TCA–1, over-all block diagram	111
108	Demultiplexing and demodulating circuit, block diagram	112
109	Modulating and multiplexing circuit, block diagram	113
110	Oscilloscope OS–25/G, functional block diagram	116
111	Video restorer, over-all block diagram	—
112	Video amplifiers V1 and V2	117
113	Rectifier-clipper V3 and shaper V4	119
114	Pulse amplifier V5A and output amplifier V5B	120
115	Circuits for modem demodulation waveshapes	122
116	Marker separator V22 and marker detector V23	123
117	Gate shaper V24 and amplifier stage V25	124
118	Modem demodulator section	125
119	Demodulator gate generator V3A and pwm converter V3B	126
120	Demodulator clipper and audio amplifier, stages V4A and V4B	126
121	Modem ringing amplifier stage V5	128
122	Delay line section	129
123	Inverter V26	130
124	Gate amplifier V27 and clipper V18A	131
125	Cathode follower-blanker V11 and shaper-mixer amplifier V12	131
126	Modem modulator, block diagram	132
127	Modem hybrid transformer connections	133
128	Modem switching circuit, simplified diagram	134
129	Clipper audio amplifier stage V1A	135
130	Pulse-position modulator V1B	136
131	Modem clipper-shaper-mixer tube V2A and mixer tube V2B	137
132	Cathode follower-amplifier V13	138
133	Party-line audio terminations	139
134	Party-line private connections	140
135	Remote keying circuit, normal operation	—
136	Remote keying circuit, remote keying operation	—
137	Remote keying, normal operation, simplified schematic	142
138	Remote keying, remote keying operation, simplified schematic diagram	143

LIST OF ILLUSTRATIONS (contd)

Fig. No. *Title* *Page*
139 Alarm circuit V16A, V18B, V17A and V15B 143
140 Alarm circuit V15A, V16B and V17B 144
141 Voltage Regulator CN–236/G, block diagram 145
142 Voltage Regulator CN–236/G, power circuit 146
143 Voltage Regulator CN–236/G, control circuit 146
144 Voltage Regulator CN–236/G, filament and full-wave rectifier bias arrangement 148
145 Power Supply PP–691/G, block diagram 150
146 Oscilloscope OS–25/G, over-all block diagram 152
147 Cathode-ray tube circuits 153
148 Oscilloscope power supply .... —
149 Oscilloscope —1,500- and —600-volt supply 155
150 Oscilloscope +1,800-volt supply 155
151 Oscilloscope +450-volt regulated supply 155
152 Oscilloscope +225-volt supply 156
153 Oscilloscope voltage calibration circuit 156
154 Oscilloscope —140-volt supply 156
155 Oscilloscope vertical attenuator 157
156 Oscilloscope vertical input amplifier 158
157 Oscilloscope cathode-follower stage V13 159
158 Oscilloscope vertical amplifier output stage 160
159 Oscilloscope horizontal sweep phase circuit 161
160 Oscilloscope trigger phase splitter V17 and sync amplifier V18 162
161 Oscilloscope multivibrator 162
162 Oscilloscope sweep generator 164
163 Oscilloscope sweep amplifier 164
164 8-kc amplifier crt blanking cathode follower V27A 166
165 Oscilloscope timing-pip-phase amplifier and sync pulse generator V28A 166
166 Oscilloscope timing-marker generator 168
167 Audio Test Set TS–762/TC, block diagram 170
168 F1A curve 170
169 Oscillator V1 and amplifier V2 172
170 Inverter V3 and push-pull amplifier V4 172
171 Amplifiers V6 and V7 174
172 Limiter V5 175
173 Shorting stick 178
174 Video restorer, top view 184
175 Video restorer, bottom view, resistors 185
176 Video restorer, bottom view, capacitors 186
177 Video restorer, bottom view, all components except resistors and capacitors 187
178 Video restorer, rear view 188
179 Video restorer, tube socket voltage and resistance diagram .... —
180 Test set-up using Multiplexer Group AN/TCA–1 (23-channel operation) .... —
181 Test set-up using Multiplexer Group AN/TCA–1 (45-channel operation) .... —
182 Modem, right side view 193
183 Modem, left side view 194

LIST OF ILLUSTRATIONS (contd)

Fig. No.	*Title*	*Page*
184	Modem test extension in position	196
185	Modem test extension with modem in position	196
186	Modem tube socket voltage and resistance diagram	197
187	Terminal balance to ground test set-up	200
188	Transhybrid test set-up	200
189	Delay line, location of parts	202
190	Mounting rack, front view	204
191	Mounting rack, rear view, door open	205
192	A-c power distribution diagram	—
193	Filament supply, air filter removed, interior view	207
194	Filament supply, back view, rear panel and remote keying units removed	208
195	Filament supply, bottom view	209
196	Remote keying unit	210
197	Power supply, interior view	212
198	Power supply, top view	213
199	Power supply, bottom view	213
200	Power supply, back view	214
201	Oscilloscope, left side view	216
202	Oscilloscope, right side view (looking down)	217
203	Oscilloscope, right side view (looking up)	219
204	Oscilloscope, rear view	220
205	Oscilloscope, back of front panel, right side view	221
206	Oscilloscope, front panel swung down	222
207	Wave form at pin 6 (plate) of V28B	223
208	Vertical amplifier adjustment wave form	224
209	Vertical attenuator adjustment wave form and crt display, voltage calibrator wave form	225
210	Capacitor C22 adjustment wave form	225
211	Vertical attenuator adjustment, C19 wave form	226
212	Vertical attenuator adjustment, C21 wave form	226
213	Wave form at pin 8 (plate) of V12	227
214	Wave form at pin 8 (plate) of V13	227
215	Wave form at pin 8 (plate) of V14	228
216	Wave form at pin 8 (plate) of V15	228
217	Wave form at pin 1 (plate) of V16A	228
218	Wave form at pin 6 (plate) of V16B	228
219	Wave form at pins 5 (cathode) and 8 (plate) of V17	228
220	Wave form at pin 8 (plate) of V18 and pin 5 (cathode) of V19A	228
221	Wave form at pin 8 (plate) of V20	229
222	Wave form at pin 8 (plate) of V21	229
223	Wave form at pin 8 (plate) of V22 and pins 1 and 5 (cathodes) of V24	229
224	Wave form at pin 5 (plate) of V25	229
225	Wave form at pin 5 (plate) of V26	229
226	Wave form at pin 1 (plate) of V28A	230
227	Wave form at pins 1 and 6 (plates) of V30	230
228	Wave form at pin 7 (grid) of V30B	230
229	Wave form at pin 6 (plate) of V31A	230

LIST OF ILLUSTRATIONS (contd)

Fig. No.	*Title*	*Page*
230	Wave form at J4	230
231	Crt display, time calibrator wave form	230
232	Oscilloscope, bottom right section, tube socket voltage and resistance diagram	231
233	Oscilloscope, bottom left section, tube socket voltage and resistance diagram	232
234	Oscilloscope, bottom center section, tube socket voltage and resistance diagram	233
235	Control monitor, top view	234
236	Control monitor, side view	235
237	Audio test set, top view	238
238	Audio test set, bottom view	239
239	Audio test set, tube socket voltage and resistance diagram	240
240	Send oscillator frequency range, test set-up	242
241	Send oscillator distortion control, test set-up	242
242	Send attenuator calibration accuracy, test set-up	243
243	Send output impedance at 1 kc, test set-up	243
244	Send output balance to ground, test set-up	244
245	Receive attenuator accuracy, test set-up	244
246	Meter calibration accuracy, test set-up	245
247	Receive input impedance at 1 kc, test set-up	246
248	Receive input balance to ground, test set-up	246
249	F1A network response, test set-up	246
250	F1A noise reading, test set-up	246
251	Distortion network reading at 970 and 1,030 cycles, test set-up	246
252	Voltage regulator, top view, showing rear of front panel	249
253	Voltage regulator, bottom view	250
254	Voltage regulator control unit, top view	250
255	Voltage regulator control unit, bottom view	250
256	Voltage regulator, tube socket voltage and resistance diagram	251
257	Impedance of party-line terminals, test set-up	258
258	Multiplexer rack, over-all schematic diagram	—
259	Pulse Form Restorer TD–68/G, over-all schematic diagram	—
260	Video restorer, over-all schematic diagram	—
261	Telephone Modem MD–179/TC, over-all schematic diagram	—
262	Electrical Equipment Rack MT–1433/TCA–1, over-all schematic diagram	—
263	Delay line, over-all schematic diagram	—
264	Multiplexer Subassembly MX–1442/TC, over-all schematic diagram	—
265	Remote Switching Control C–1509/TC, over-all schematic diagram	—
266	Oscilloscope OS–25/G, over-all schematic diagram	—
267	Audio Test Set TS–762/TC, over-all schematic diagram	—
268	Control Monitor C–1151/TC, over-all schematic diagram	—
269	Power Supply PP–691/G, over-all schematic diagram	—
270	Voltage Regulator CN–236/G, over-all schematic diagram	—
271	Switch Box SA–357/G, over-all schematic diagram	—
272	Electrical Connector Assembly J–535/G, over-all schematic diagram	—
273	Multiplexer rack, over-all wiring diagram	—
274	Pulse Form Restorer TD–68/G, over-all wiring diagram	—

LIST OF ILLUSTRATIONS (contd)

Fig. No.	*Title*	*Page*
275	Video restorer, over-all wiring diagram	—
276	Telephone Modem MD–179/TC, over-all wiring diagram	—
277	Electrical Equipment Mounting Rack MT–1433/TCA–1, over-all wiring diagram	—
278	Delay line, over-all wiring diagram	—
279	Multiplexer Subassembly MX–1442/TC, over-all wiring diagram	—
280	Remote Switching Control C–1509/TC, over-all wiring diagram	—
281	Oscilloscope OS–25/G, over-all wiring diagram	—
282	Audio Test Set TS–762/TC, over-all wiring diagram	—
283	Control Monitor C–1151/TC, over-all wiring diagram	—
284	Power Supply PP–691/G, over-all wiring diagram	—
285	Voltage Regulator CN–236/G, over-all wiring diagram	—
286	MIL-STD Resistor color code	—
287	MIL-STD Capacitor color code	—

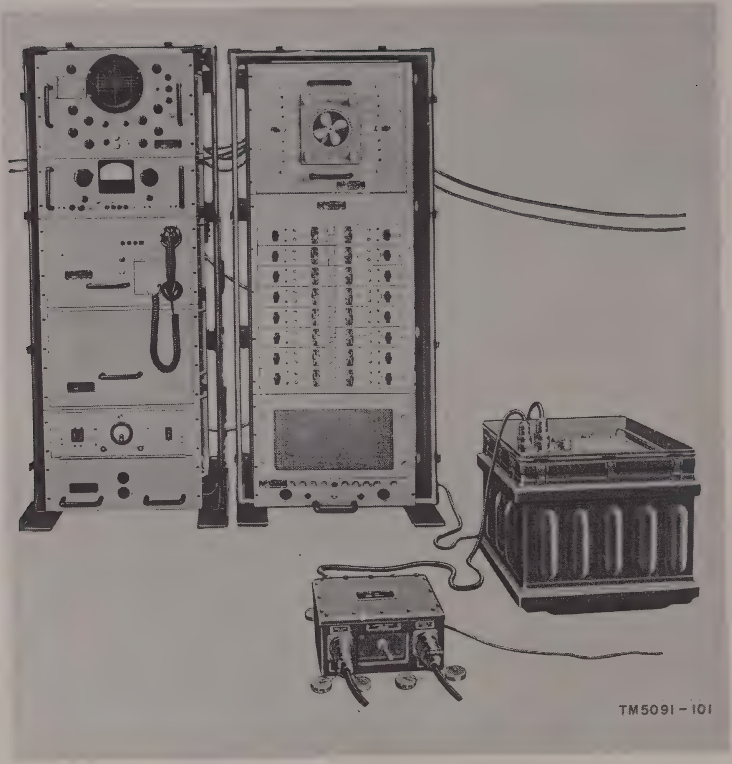


Figure 1. Typical installation of Multiplexer Group AN/TCA–1.

Note. This manual will be replaced by TM 11–2141 which, when published, will be listed in Department of the Army Pamphlet 310–4.

CHAPTER 1
INTRODUCTION

Section I. GENERAL

1. Scope

a. General. This manual contains information for the installation, operation, maintenance, theory, trouble shooting, and repair of Multiplexer Group AN/TCA–1 (fig. 1).

b. Terminology. The following terminology is used throughout this book:

(1) *Voice-frequency channel.* Any channel that operates between 300 to 3,500 cycles per second (cps).

(2) *Time-division multiplex (tdm).* A system of simultaneously transmitting many channels by time sharing.

(3) *Pulse-position modulation (ppm).* A method of modulation in which the information is transmitted by the *position* of a pulse with relation to a reference time.

(4) *8-kc sampling.* The rate at which the voice-frequency (v-f) channels are sampled.

(5) *Pulse train.* A double marker pulse and 23 channel pulses that recur at the regular 8-kilocycle (kc) sampling rate.

(6) *Pulse-position modulator (modulator).* The channel unit that converts audio signals into ppm pulses.

(7) *Pulse-position demodulator (demodulator).* The channel unit that converts ppm channel pulses into audio signals.

(8) *Ppm multiplexer (multiplexer).* A unit that combines the individual channel ppm pulses to give a single tdm train of pulses.

(9) *Ppm demultiplexer (demultiplexer).* A unit that separates a tdm train of pulses into the individual ppm pulses.

(10) *Drop and insert (D & I).* The demodulation of a given channel, the *dropping* of the original pulse, and the insertion of the locally generated pulse in its place in the pulse train.

(11) *Party-line operation.* An operation permitting a telephone circuit at a repeater point to be bridged onto a given channel so that personnel on the telephone circuit can converse with both terminals and/or other repeaters (when also connected for party-line operation).

(12) *Private-line operation.* An operation which is the opposite of party-line operation. That is, a telephone circuit at a repeater point connected for private-line operation will permit personnel on the telephone circuit to converse only with a terminal or repeater in one given direction.

(13) *Blanking.* The elimination of the original channel pulse from the pulse train.

2. Forms and Records

The following forms will be used for reporting unsatisfactory conditions of Army materiel and equipment and in performing preventive maintenance.

a. DD Form 6, Report of Damaged or Improper Shipment, will be filled out and forwarded as prescribed in SR 745–45–5 (Army).

b. DA Form 468, Unsatisfactory Equipment Report, will be filled out and forwarded to the Office of the Chief Signal Officer, as prescribed in SR 700–45–5.

c. DA Form 11–238, Operator First Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar), will be prepared in accordance with instructions on the back of the form (fig. 57).

d. DA Form 11–239, Second and Third Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar), will be prepared in accordance with instructions on the back of the form (fig. 58).

e. Use other forms and records as authorized.

Section II. DESCRIPTION AND DATA

3. Purpose and Use

a. Multiplexer Group AN/TCA–1 is designed primarily for use as a drop and insert terminal at a radio link in a microwave communication system. The multiplexer group provides eight communication channels at a repeater station. Its use is limited to a system using Multiplexer Sets AN/TCC–13 as terminals.

b. The multiplexer group is also used to restore the 23- or 45-channel pulse train, received from a radio receiver, into a standard waveshape before it is fed to the radio transmitter. The multiplexer group usually is placed between two Radio Sets AN/TRC–29 at a drop and insert repeater station.

c. Multiplexer Group AN/TCA–1 will provide the following facilities at a drop and insert repeater:

(1) Eight v-f communication channels, which can be used for voice, signal telemetering, facsimile, or v-f telegraph.

(2) Each channel can be dropped for local use or passed on a through basis.

(3) Channel 1 (the order-wire channel) and channel 2 can be used on a private- or party-line basis. Channels 3 through 8 can be used only for private operation. For private operation, each channel can be on a two-wire or four-wire basis.

(4) Channels 1 and/or 2 can be used for order-wire operation and normal communication. Order-wire operation enables the operators of the communication link to communicate with each other for maintenance and testing.

(5) Channels 1 and 2 can be used for remote keying between very-high frequency (vhf) mobile equipments to extend the range of mobile communications over the radio-relay communication system of which the multiplexer group is a part. The remote keying facility on each channel is provided only on a party-line basis. This party-line operation furnishes the audio signal on a two-wire connection so that a hybrid is required in the vhf equipment to separate the receiver and transmitter signals.

(6) Ringing circuits permit the transmission of a 20-cps signal to call the operator at the other end of the channel.

(7) An alarm circuit is included to indicate the failure of inputs, outputs, and high noise levels. The alarm circuit also disables local ringing to eliminate false ringing on the channels.

Note. Should the equipment become disabled, the alarm circuit will automatically bypass the multiplexer group, causing no interruption in terminal-to-terminal traffic. If this happens, there are no drop and insert facilities available at the repeater.

(8) Test equipment that is necessary for the complete alignment and maintenance of the multiplexer group is also provided.

4. System Application

a. General.

(1) Multiplexer Set AN/TCC–13, two Radio Sets AN/TRC–29 (one spare), and auxiliary components comprise Radio Telephone Terminal Set AN/TRC–38, which is a terminal station in a radio-relay system. Two terminal sets, with repeater stations as required, comprise a tdm radio-relay system (fig. 2). This system provides multichannel telephone trunk service between the two terminals of the radio-relay system. For convenience, these terminals are called *east* and *west.*

(2) Multiplexer Group AN/TCA–1, inserted between two Radio Sets AN/TRC–29 at a repeater station (fig. 3), can be used to extract the first eight audio channels included in the tdm signal, and to insert these audio channels back into the tdm signal. Therefore, it is possible to provide branching use of eight telephone channels at the repeater station. Eight channels are inserted or dropped from each of two pulse trains; therefore, the multiplexer group can provide 16 channels (eight channels directed at each terminal). An eight-channel drop repeater equipment consisting of three Radio Sets AN/TRC–29 (one spare) and one Multiplexer Group AN/TCA–1 is nomenclatured as Radio Repeater Set AN/TRC–41.

b. Single-Hop Tdm Radio-relay System. Refer to figure 2 as an example of the use of a single-hop tdm radio-relay system.

(1) At the *west* terminal, the incoming v-f telephone signals are fed into the modulator and multiplexer portion of Multiplexer Set AN/TCC–13 and converted into a series of ppm-tdm pulses. These pulses are fed to Radio Set AN/TRC–29 to frequency-modulate the transmitter. The modulated microwave carrier is then fed to an antenna and transmitted to the *east* terminal. With the duplexer, one antenna can be used for both transmitter and receiver.

(2) The antenna at the *east* terminal picks up the signal and feeds it to the radio receiver of Radio Set AN/TRC–29, where it is amplified and detected. The receiver output consists of a series of ppm-tdm pulses that are fed to the demultiplexer and demodulator portion of Multiplexer Set AN/TCC–13. Here the pulses are separated and demodulated and the audio signals are distributed to the telephone lines.

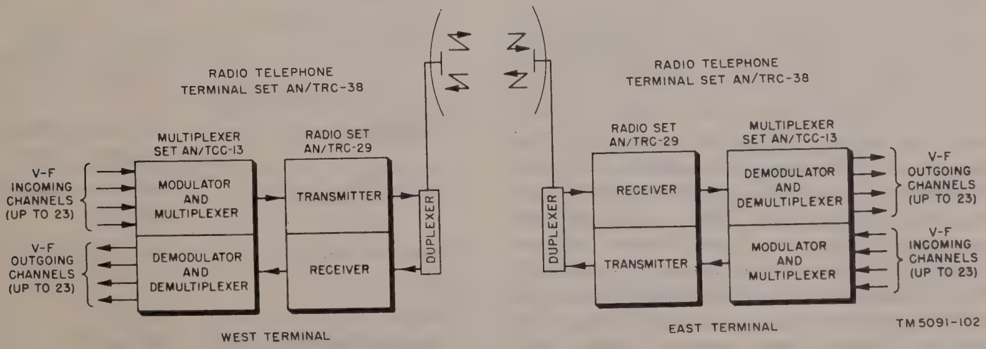

RADIO TELEPHONE TERMINAL SET AN/TRC-38
MULTIPLEXER SET AN/TCC-13
RADIO SET AN/TRC-29
V-F INCOMING CHANNELS (UP TO 23)
MODULATOR AND MULTIPLEXER
TRANSMITTER
DUPLEXER
V-F OUTGOING CHANNELS (UP TO 23)
DEMODULATOR AND DEMULTIPLEXER
RECEIVER
WEST TERMINAL
RADIO TELEPHONE TERMINAL SET AN/TRC-38
RADIO SET AN/TRC-29
MULTIPLEXER SET AN/TCC-13
DUPLEXER
RECEIVER
DEMODULATOR AND DEMULTIPLEXER
V-F OUTGOING CHANNELS (UP TO 23)
TRANSMITTER
MODULATOR AND MULTIPLEXER
V-F INCOMING CHANNELS (UP TO 23)
EAST TERMINAL
TM 5091-102

Figure 2. Single hop tdm radio-relay system, block diagram.

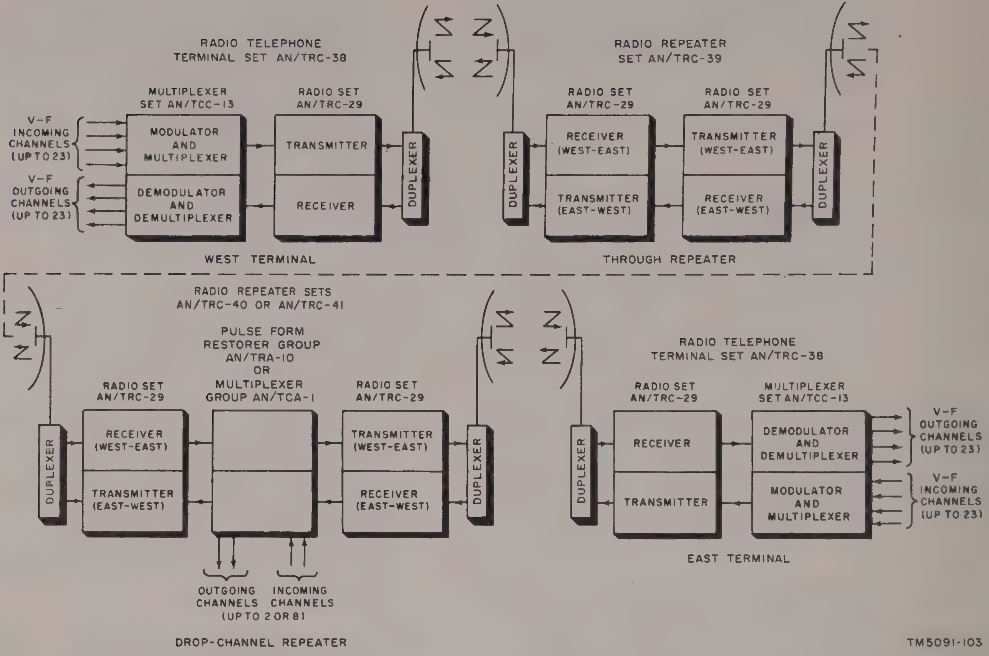

RADIO TELEPHONE TERMINAL SET AN/TRC-38
MULTIPLEXER SET AN/TCC-13
RADIO SET AN/TRC-29
V-F INCOMING CHANNELS (UP TO 23)
V-F OUTGOING CHANNELS (UP TO 23)
MODULATOR AND MULTIPLEXER
DEMODULATOR AND DEMULTIPLEXER
TRANSMITTER
RECEIVER
DUPLEXER
WEST TERMINAL
RADIO REPEATER SET AN/TRC-39
RADIO SET AN/TRC-29
RADIO SET AN/TRC-29
RECEIVER (WEST-EAST)
TRANSMITTER (EAST-WEST)
TRANSMITTER (WEST-EAST)
RECEIVER (EAST-WEST)
DUPLEXER
DUPLEXER
THROUGH REPEATER
RADIO REPEATER SETS AN/TRC-40 OR AN/TRC-41
PULSE FORM RESTORER GROUP AN/TRA-10 OR MULTIPLEXER GROUP AN/TCA-1
RADIO SET AN/TRC-29
RADIO SET AN/TRC-29
DUPLEXER
RECEIVER (WEST-EAST)
TRANSMITTER (EAST-WEST)
TRANSMITTER (WEST-EAST)
RECEIVER (EAST-WEST)
DUPLEXER
OUTGOING CHANNELS
INCOMING CHANNELS
(UP TO 2 OR 8)
DROP-CHANNEL REPEATER
RADIO TELEPHONE TERMINAL SET AN/TRC-38
RADIO SET AN/TRC-29
MULTIPLEXER SET AN/TCC-13
DUPLEXER
RECEIVER
TRANSMITTER
DEMODULATOR AND DEMULTIPLEXER
MODULATOR AND MULTIPLEXER
V-F OUTGOING CHANNELS (UP TO 23)
V-F INCOMING CHANNELS (UP TO 23)
EAST TERMINAL
TM5091-103

Figure 3. Multiple hop tdm radio-relay system, block diagram.

(3) The reverse communication path (from the *east* to the *west* terminal) is accomplished in the same manner as described in subparagraphs (1) and (2) above.

c. A Multiple-hop Tdm Radio-relay System (fig. 3). Refer to figure 3 as an example of a multiple-hop, tdm radio-relay system. The terminals of this system consist of Multiplexer Set AN/TCC–13 and Radio Set AN/TRC–29. At through repeater stations, where no multiplexing or demultiplexing equipment is used, the video output of the radio receiver is fed directly into the radio transmitter. To drop channels to an audio basis or to insert them at a repeater station (called a drop-channel repeater station), a Pulse Form Restorer Group AN/TRA–10 or Multiplexer Group AN/TCA–1 equipment is used, depending on the desired number of channels to be dropped or inserted. Pulse Form Restorer Group AN/TRA–10 provides facilities for two drop and insert channels for each direction of transmission, and Multiplexer Group AN/TCA–1 provides facilities for eight drop and insert channels for each direction of transmission.

5. Technical Characteristics

Audio channel:

Input level for full modulation	0 dbm, 2 wire; –4 dbm, 4 wire.
Output level for full modulation	–3 dbm, 2 wire; 0 dbm, 4 wire.
Output level range	–20 dbm to +7 dbm.
Termination	600 ohms, 2 wire or 4 wire.
Signaling	20 cps.
Modulating bandwidth	300 cps to 3,500 cps.

Signal-to-noise ratio (F1A)	60 db min (one hop).
Signal-to-cross talk ratio	55 db min (one hop).
Distortion	4 per cent max.

General:

Type of modulation	Ppm.
Type of multiplexing	Tdm.
Number of drop channels	8.

Party-line operation audio connections (2 wire only, 600 ohms):

Input level	0 dbm.
Output level from terminal to repeater	–7 dbm.
Output level from repeater to repeater	–10 dbm.

Video characteristics:

Pulse deviation	±.5 microsecond 2 +100 per cent modulation.
Pulse rate	192 kc.
Pulse rise time	.3 microsecond.
Pulse width	.6 microsecond.
Impedance	50 ohms.
Amplitude	.22 to .66 volt (23 channel) .45 to .9 volt (45 channel)
Bandwidth	1 mc.

Audio Test Set TS–762/TC:

Test frequency	1,000 cps.
Test level	–35 to +10 dbm.
Level measurement	–70 to +10 dbm.
Filters	F1A for noise weighting; 1,000-cps rejection for distortion.

Oscilloscope OS–25/G:

Bandwidth	6 mc.
Vertical sensitivity	2.5 volts per cm max with 10:1 probe; .3 to .25 volt per cm max without probe.
Time base	5,000 to .5 microsecond per cm.
Presentation	5 in. cathode-ray tube.

Power:

Voltage	115 ±10 per cent or 230 ±10 per cent, 47.5 to 63 cps.
Consumption	1.1 kw (including oscilloscope and test set).

6. Packaging Data

a. Export Shipment. When packaged for shipment, the components of Multiplexer Group AN/TCA–1 are placed in moisture-vaporproof containers, and are packed in six crates.

b. Crating. The multiplexer group is never used alone. It is always shipped as part of a radio-relay system. The chart below describes the six crates that contain the multiplexer group.

Note. Items may be packed in a manner different from that shown, depending on the supply channel.

c. Packaging Data Chart.

Crate No.	Height (in.)	Width (in.)	Depth (in.)	Volume (cu ft)	Weight (lb)	Contents
1 of 6	74-¾	39-½	35-⅝	60.8	880	Multiplexer rack
2 of 6	74-¾	39-½	35-⅝	60.8	900	Test rack
3 of 6	29-⅛	24	30-⅛	12.2	290	Voltage regulator
4 of 6	23-½	29-¾	24-⅛	9.8	176	Spare parts case I
5 of 6	23-½	29-¾	24-⅛	9.8	200	Spare parts case II
6 of 6	12	29-½		6.1	130	Cable reel
Total					2,576	

7. Nomenclature Assignments

A list of the nomenclature assignments for the components of Multiplexer Group AN/TCA–1 (multiplexer group) follows. The common name is given after each component.

Nomenclature	Common name
Accessories Case CY–1334/G	Accessories case
Audio Test Set TS–762/TC	Test set; transmission measuring set, audio test set
Chest CY–250/U	Chest
Control Monitor C–1151/TC	Control monitor
Electrical Standardized Components Case CY–1280/U	Standardized components case, transit case, equipment mounting rack
Electrical Connector Assembly J–535/G	Connector assembly, modem test extension
Electrical Equipment Rack MT–1433/TCA–1	Mounting rack
Multiplexer Subassembly MX–1442/TC	Filament supply, multiplexer subassembly
Oscilloscope OS–25/G	Oscilloscope
Power Supply PP–691/G	Power supply
Pulse Form Restorer TD–68/G	Video restorer, pulse form restorer
Remote Switching Control C–1509/TC	Remote keying unit
Switch Box SA–357/G	Switch box
Telephone Modem MD–179/TC	Modem
Voltage Regulator CN–236/G	Voltage regulator

8. Table of Components

Note. This list is for general information only. See appropriate supply publications for information pertaining to requisition of spare parts.

a. Multiplexer Rack.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Electrical Standardized Components Case CY–1280/U, containing:	1	26-½	27	60	24.9	515
Pulse Form Restorer TD–68/G	1	19	19			
Electrical Equipment Rack MT–1433/TCA–1	1	19	19			
Delay line	1	5	5-¼			

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Telephone Modem MD–179/TC	16	16	2-½	8-½		
Multiplexer Subassembly MX–1442/TC	1	19	17-¼	8-½		
Remote Switching Control C–1509/TC	2	4-½	2-¾	5-½		

b. Test Rack.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Electrical Standardized Components Case CY–1280/U, containing:	1	26-½	27	60	24.9	534
Oscilloscope OS–25/G	1	19	19	13		
Audio Test Set TS–762/TC	1	19	19	7		
Control Monitor C–1151/TC	1	19	19	10-½		
Accessories Case CY–1334/G, containing:	1	19	19	11-¾		
Tube puller	2					
Pin straightener	2					
Wrench	2					
Power Supply PP–691/G	1	19	19	12		

c. Voltage Regulator.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Voltage Regulator CN–236/G	1	23	17-½	19-½	5.31	215

d. Spare Parts Case 1.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Chest CY–250/U, containing:	1	27	21-¼	20	6.56	126
Manual	2					
Electron tube, JAN 0A2	2					
0A3	1					
0B2	1					
2X2A	1					
5CP1A	1					
5R4WGY	2					
6AG5	7					
6AG7	9					
6AS7G	1					

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
6AU6	1					
6X4W	1					
12AT7	2					
12AT7WA	12					
5726/6AL5W	5					
5727/2D21W	1					
6005/6AQ5W	1					
Lamp, incandescent, 3 watts GE No. 356-125	1					
Lamp, resistance, WE No. 13D	1					
Tube extractor	1					
Book of schematics	1					

e. Spare Parts Case 2.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Chest CY–250/U, containing:	1	27	21-¼	20	6.56	150
Switch Box SA–357/G	1	6	11	5		
Electrical Connector Assembly J–535/G	1	30-½	8-¾	9		
Spare parts box, containing:						
Brush assembly, Powerstat type S373P	1					
Crystal unit, rectifier, JAN 1N34A	1					
Crystal unit, rectifier, JAN 1N38A	12					
Fuse, cartridge:						
1/10 amp, 125 V	6					
1/10 amp, 250 V	6					
3/10 amp, 125 V	6					
3/10 amp, 250 V	24					
6/10 amp, 250 V	12					
1 amp, 125 V	6					
1.5 amp, 125 V	6					
2 amps, 125 V	30					
3 amps, 125 V	12					
4 amps, 125 V	12					
5 amps, 125 V	12					
8 amps, 125 V	6					
10 amps, 32 V	12					
Lamp, glow, type NE–51	8					
Lightning arrestor assembly	4					

Component	Required No.	Length (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Cord CG–409C/U	4	300				
Cable Assembly CG–1040A/U	2	183				
Cable Assembly CX–2272/U	1	41				
Cable Assembly CX–2273/U	1	124				
Cable Assembly CX–2275/U	1	100				
Cable Assembly CX–2276/U	1	76				
Cable Assembly CX–2277/U	1	100				
Cable Assembly CX–2440/U	1	180				
Cable Assembly CX–2441/U	2	100				
Cable Assembly CX–2442/U	2	120				
Cable Assembly CX–2682/U	1	39				
Electrical Lead CX–2683/U	1	240				

f. Cable Reel and Cable.

Component	Required No.	Length (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Cable Reel RC–405/TR with Cable Assembly CX–2440/U (150 ft)	1	28 dia		12	4.27	108

9. Component Arrangement of Multiplexer Group AN/TCA–1

a. All the major components of Multiplexer Group AN/TCA–1, except Voltage Regulator CN–236/G, are mounted in two transit cases. One case with components is referred to as the *multiplexer rack,* and the other is referred to as the *test rack.*

b. Voltage Regulator CN–236/G is housed in its own cabinet and is within 15 feet of the multiplexer rack. A description of the voltage regulator is given in paragraph 25.

c. Descriptions of the other minor components of the multiplexer group are given in paragraphs 26 and 27.

10. Description of Electrical Standardized Components Case CY–1280/U

(fig. 4 and 5)

a. Electrical Standardized Components Case CY–1280/U consists of an equipment mounting rack and two covers. The two covers are identical and interchangeable and can be completely removed from the equipment mounting rack. Three carrying handles and a rope hook are bolted to each side of the equipment mounting rack. One carrying handle is on top of the case. The rope hooks are used when lifting the transit case with a crane. An air escape valve is on the right side of the rack. When the equipment is transported by air, the valve is opened to insure equal air pressure inside and outside the transit case; otherwise, the valve is closed.

b. The equipment mounting rack consists of an outer shell, shock-mounted to a metal mounting frame with drilled and tapped mounting holes. The components are mounted on this inner frame with screws. Two metal feet are bolted to the bottom of the outer case. These feet project to the front and rear to balance the rack when the covers are removed and the equipment is installed.

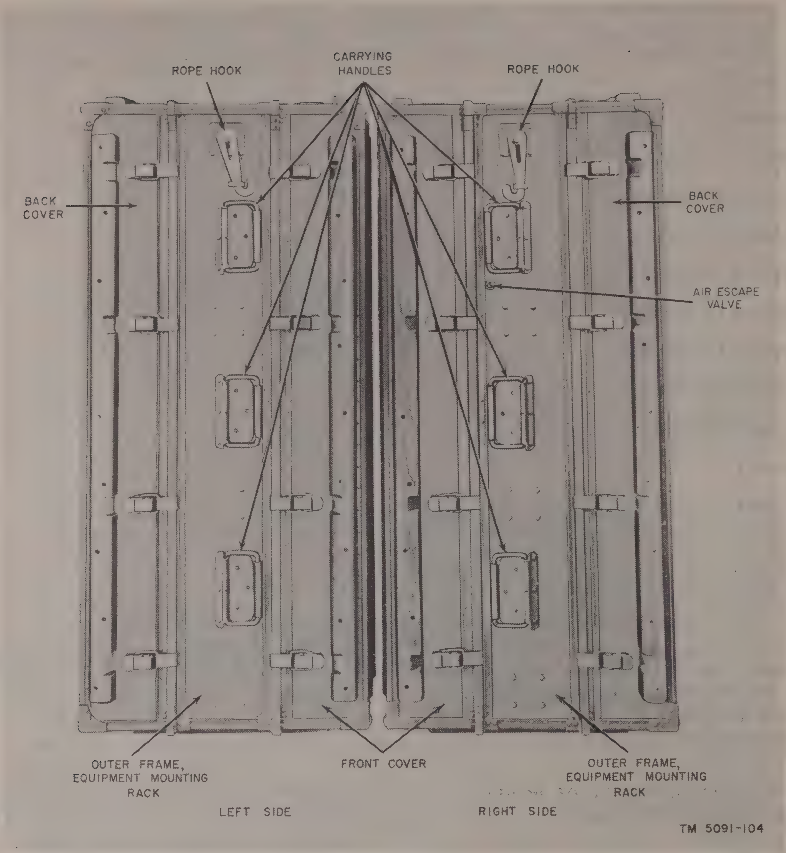

CARRYING HANDLES
ROPE HOOK
ROPE HOOK
BACK COVER
BACK COVER
AIR ESCAPE VALVE
OUTER FRAME, EQUIPMENT MOUNTING RACK
FRONT COVER
OUTER FRAME, EQUIPMENT MOUNTING RACK
LEFT SIDE
RIGHT SIDE
TM 5091-104

Figure 4. Electrical Standardized Components Case CY–1280/U.

11. Description of Multiplexer Rack

The multiplexer rack (fig. 6 and 7) consists of Electrical Standardized Components Case CY–1280/U (par. 10) and the components listed below.

a. Pulse Form Restorer TD–68/G (par. 12).

b. Electrical Equipment Rack MT–1433/TCA–1 (par. 13) with delay line (par. 15).

c. Twenty-four Telephone Modems MD–179/TC (par. 14).

d. Multiplexer Subassembly MX–1442/TC (par. 16).

e. Two Remote Switching Controls C–1509/TC (par. 17).

12. Description of Pulse Form Restorer TD–68/G

a. The pulse form restorer, mounted at the top of the equipment rack (fig. 6), consists of two identical chassis (each called a video restorer), one for each direction, mounted side by side. The pulse form restorer contains the reshaping, multiplexing, and demultiplexing circuits that are common to every channel. As noted on the front panel (fig. 32), the eastgoing video restorer is located on the left side, and the westgoing video restorer is located on the right side.

b. The front panel contains test pin jacks and fuses for both the eastgoing and westgoing video restorers.

c. The two rear sides of the pulse form restorer have all the connectors for the interconnecting cables. From the rear of the unit the eastgoing video restorer is on the right side, and the westgoing video restorer is on the left side.

(1) The right side rear chassis (fig. 28) mounts the following connectors: EASTGOING SCOPE SYNC, INPUT FROM WESTFACING REC, and OUTPUT TO WESTFACING XMTR.

(2) The left side rear chassis has the following connectors: EASTGOING SCOPE SYNC, INPUT FROM EASTGOING REC, and OUTPUT TO WESTFACING XMTR.

13. Description of Electrical Equipment Rack MT–1433/TCA–1

Electrical Equipment Rack MT–1433/TCA–1 is attached to Electrical Standardized Components Case CY–1280/U (fig. 6 and 7) to provide mounting facilities for the 16 modems, delay line, remote keying units, and audio terminations.

a. Sixteen modems (one for each direction, two for each channel) are mounted on the front of the mounting rack in two vertical rows of eight each. Each modem is secured to the mounting rack by two knurled thumbscrews, one on each side of the modem front panel. The modem slides in or out. The mounting rack contains a mating receptacle for each modem to connect the modem to the mounting rack.

b. The delay line mounts to the rear of the mounting rack in a vertical position. All the eastfacing and westfacing channel audio binding posts (four binding posts for each channel) as well as the channels 1 and 2 party line binding posts are located at each side of the delay line. Above each binding post is the surge protection block. The two 4W REC 2W LINE

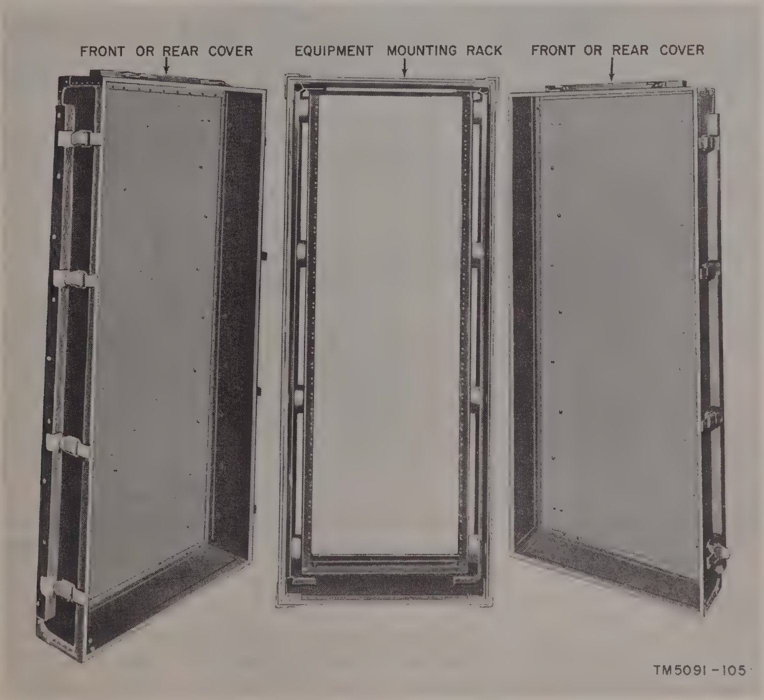


Figure 5. Electrical Standardized Components Case CY–1280/U, covers removed.

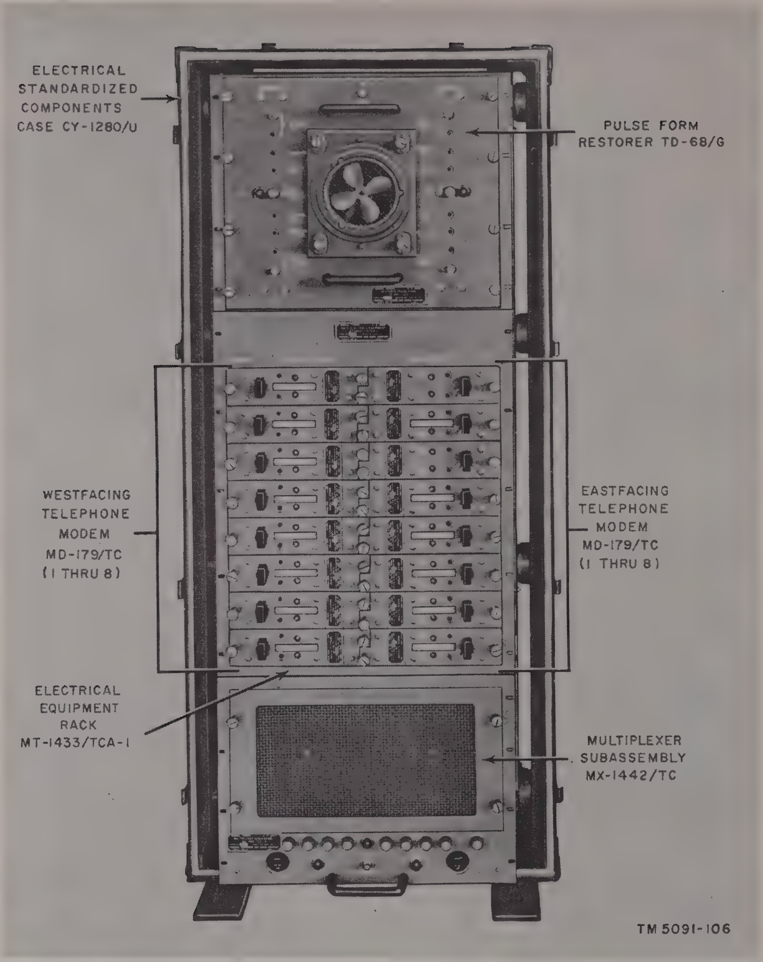

ELECTRICAL STANDARDIZED COMPONENTS CASE CY-1280/U
PULSE FORM RESTORER TD-68/G
WESTFACING TELEPHONE MODEM MD-179/TC (1 THRU 8)
EASTFACING TELEPHONE MODEM MD-179/TC (1 THRU 8)
ELECTRICAL EQUIPMENT RACK MT-1433/TCA-1
MULTIPLEXER SUBASSEMBLY MX-1442/TC
TM 5091-106

Figure 6. Multiplexer Group AN/TCA–1, multiplexer rack, front view.

binding posts are used on a four-wire basis as the receiving pair, and on a two-wire basis as the line connections. The 4W TRANS binding posts are used on a four-wire basis as the transmitting pair.

14. Description of Telephone Modem MD–179/TC

a. Sixteen modems in two vertical columns of eight units each are mounted directly below the pulse form restorer (fig. 6). Each modem consists of three sections: the modulator, demodulator, and 20-cycle ringing section. Each modem is secured to the mounting rack by two knurled captive screws, and is connected through a male plug at the rear of the modem, which slides into a female receptacle on the mounting rack.

b. The front panel of each modem contains a five-position selector switch, two test jacks, and two recessed screw-driver adjustment potentiometers. The selector switch permits the modem to operate normally, or to permit direct connection to the audio test set for testing. The

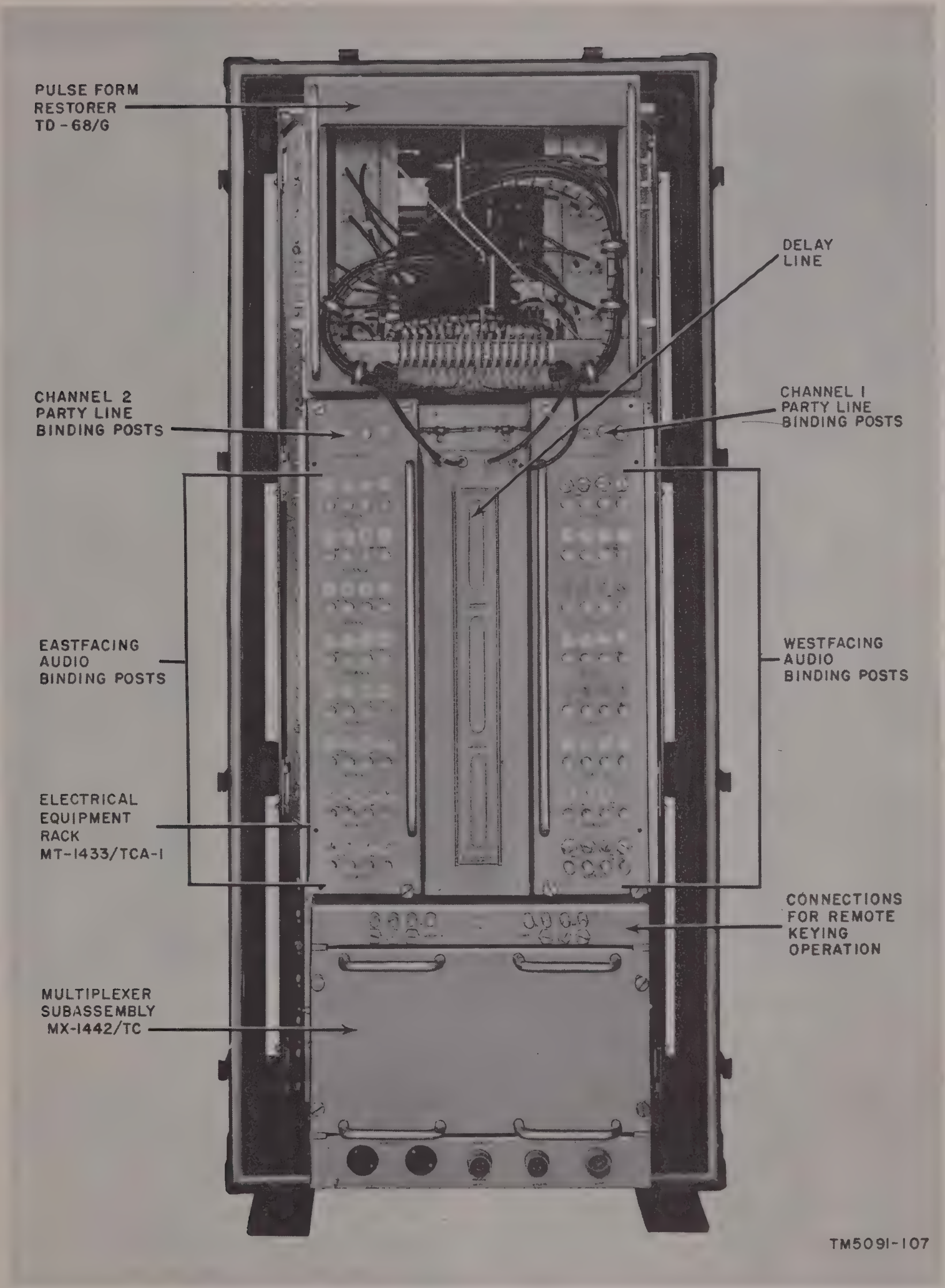

PULSE FORM RESTORER TD-68/G
DELAY LINE
CHANNEL 2 PARTY LINE BINDING POSTS
CHANNEL 1 PARTY LINE BINDING POSTS
EASTFACING AUDIO BINDING POSTS
WESTFACING AUDIO BINDING POSTS
ELECTRICAL EQUIPMENT RACK MT-1433/TCA-1
CONNECTIONS FOR REMOTE KEYING OPERATION
MULTIPLEXER SUBASSEMBLY MX-1442/TC
TM5091-107

Figure 7. Multiplexer Group AN/TCA-1, multiplexer rack, rear view.

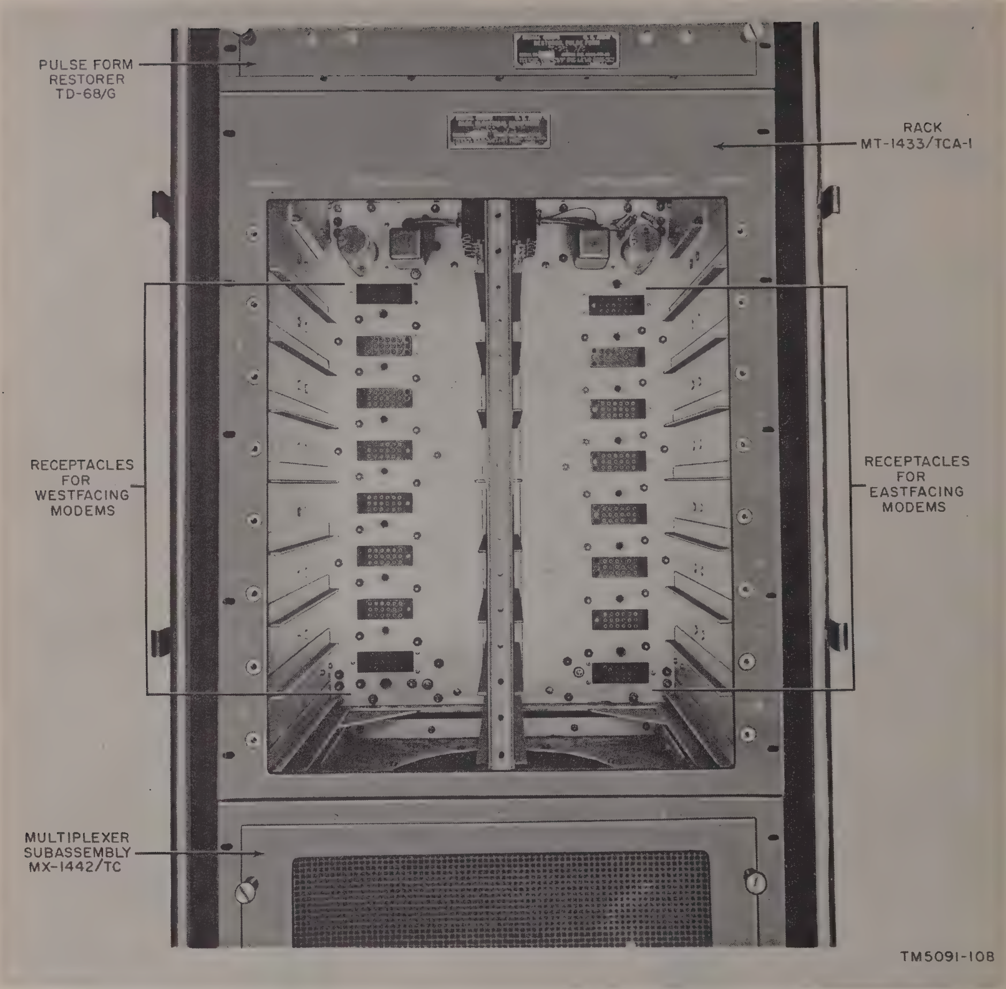

PULSE FORM RESTORER TD-68/G
RACK MT-1433/TCA-1
RECEPTACLES FOR WESTFACING MODEMS
RECEPTACLES FOR EASTFACING MODEMS
MULTIPLEXER SUBASSEMBLY MX-1442/TC
TM5091-108

Figure 8. Multiplexer rack, front view, 16 Modems MD–179/TC removed.

two test jacks are marked PWM (pulse-width modulation) and PPM (pulse-position modulation). They facilitate trouble-shooting the unit with the oscilloscope. The two screwdriver adjustment potentiometers are OUTPUT AUDIO GAIN and PULSE POSITION.

15. Description of Delay Line

A delay line assembly is mounted vertically on the rear of the mounting rack (fig. 7). There are two electrically independent delay line sections associated with each direction of transmission, one for the multiplexer half of the video restorer and one for the demultiplexer half of the video restorer. Consequently, there are a total of four electrically independent delay line sections in the one delay line assembly. Each of the delay line sections provides eight separate outputs, each output delayed by 5.2 microseconds from the previous one to maintain the time position of the channels. These outputs are applied to the 16 modems. Four connectors at the top provide appropriate input gate connections.

16. Description of Multiplexer Subassembly MX–1442/TC (Filament Supply)

a. Multiplexer Subassembly MX–1442/TC is the bottom unit in the multiplexer rack (fig. 6 and 7). It is the filament supply for the multiplexer group.

b. The front panel of the filament supply contains the following panel components across the top row: two filament fuses for the left side modems, two filament fuses for the right side modems, an alarm indicator lamp, four B+ fuses, and a fuse for the fan.

c. The bottom row contains a 115-volt alternating-current (a-c) convenience outlet, an a-c *power* indicator lamp, an audible alarm disconnect push button, a B+ *power* indicator lamp, and a second convenience outlet.

d. The top rear of the filament supply contains binding post connections for the remote keying units (channels 1 and 2 only).

e. The bottom rear of the filament supply contains two convenience outlets, two connectors for applying 115-volt a-c and B+ power for the entire multiplexer rack, and a jack for connecting the test set to the test pair. The test pair is common to each modem and permits the operator to connect the test set to any modem for testing purposes.

17. Description of Remote Switching Control C–1509/TC

(fig. 9)

The remote keying unit is a plug-in type unit 5-5/16 inches long by 2-5/8 inches wide by 3-17/32 inches deep, and is mounted on the rear of Multiplexer Subassembly MX–1442/TC. The remote keying unit is part of and operates only with the multiplexer subassembly. During normal operation, the unit is plugged in so that the arrow marked NORMAL OPERATION is pointing upward. To permit remote operation of a vhf radio station, the unit is pulled out, inverted, and then replaced so that the arrow marked REMOTE KEYING OPERATION is pointing upward. Two of these units are supplied as part of the multiplexer group to permit remote keying operation on channel 1 and/or 2.

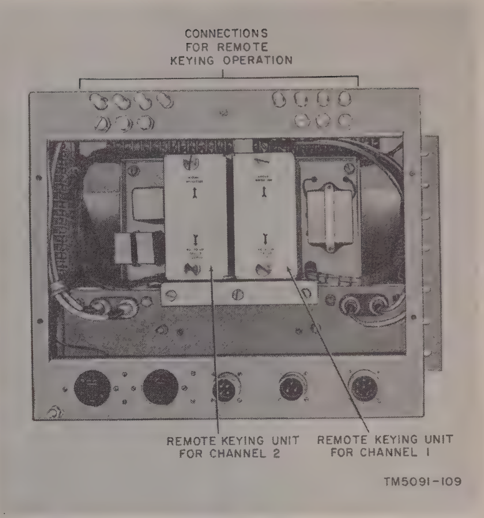

CONNECTIONS FOR REMOTE KEYING OPERATION
REMOTE KEYING UNIT FOR CHANNEL 2
REMOTE KEYING UNIT FOR CHANNEL 1
TM5091-109

Figure 9. Multiplexer subassembly, rear cover removed, showing location of remote keying units.

18. Description of Test Rack

(fig. 10 and 11)

The test rack contains the test equipment, B+ power supply, and storage compartment for the multiplexer group. It consists of Electrical Standardized Components Case CY–1280/U (par. 10) and the components listed below.

a. Oscilloscope OS–25/G (par. 19).

b. Audio Test Set TS–762/TC (par. 20).

c. Control Monitor C–1151/TC (par. 21).

d. Accessories Case CY–1334/G (par. 22).

e. Power Supply PP–691/G (par. 23).

19. Description of Oscilloscope OS–25/G

Oscilloscope OS–25/G is mounted at the top of the test rack (fig. 10 and 11) by eight captive screws (four on each side). The unit is self-contained and includes its own power supply, fan, controls, fuses, and indicator

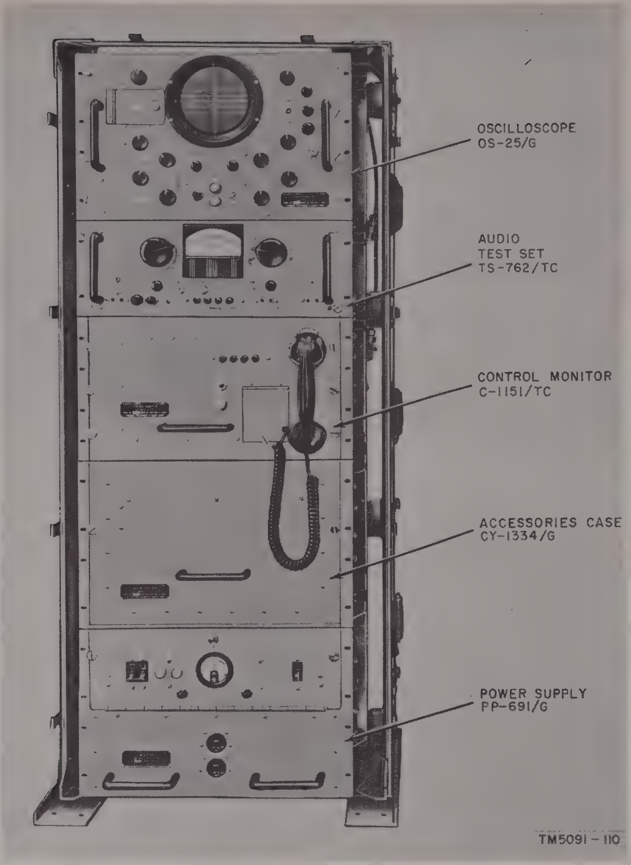


Figure 10. Multiplexer Group AN/TCA–1, test rack, front view.

lamp. It also contains special timing-pip circuits and controls to facilitate testing and trouble-shooting the multiplexer group, as well as performing video adjustments. In the upper left corner of the front panel a small compartment contains a probe and RF Cable Assembly CG–530A/U. The screen of the cathode-ray tube is protected by a lucite graticule with a green screen that is calibrated in centimeters along the horizontal and vertical axis. The rear of the oscilloscope contains jacks that connect the synchronizing signals to the oscilloscope, and also contains the power-input connector, screw-driver adjustments, test jacks for B+ voltages, and a .3-ampere fuse for the fan.

20. Description of Audio Test Set TS–762/TC

(fig. 10 and 11)

a. Audio Test Set TS–762/TC contains a 1,000-cps oscillator, metering circuits, and precision attenuators to provide the load for an accurately calibrated test tone over any channel and to measure accurately the received amplitude, signal-to-noise ratio, and distortion on any channel. Also, the test set includes the circuits and controls necessary to calibrate accurately the instrument itself.

b. A decibel meter, calibrated from –20 to +3 decibels (db), is mounted at the top center of the front panel. At the left of this meter is the precision step attenuator used for establishing the transmission level. At the right of this meter is the RECEIVED DBM step attenuator.

c. The front panel bottom row contains: two jacks used for sending out the test signal, a fuse, a power indicator lamp, a power toggle switch, a potentiometer control for calibrating the 1,000-cycle test signal, two push buttons for calibrating the output signal and the receiving amplifier, two push buttons to permit measuring the incoming test signal (one noise weighted by the F1A curve and one to check for distortion at 1,000 cps), two jacks for monitoring the received signal, a potentiometer control for calibrating the receiving amplifier, and two jacks for receiving the test signal.

d. The rear of the unit contains connectors for the input and output signals, and for the input power.

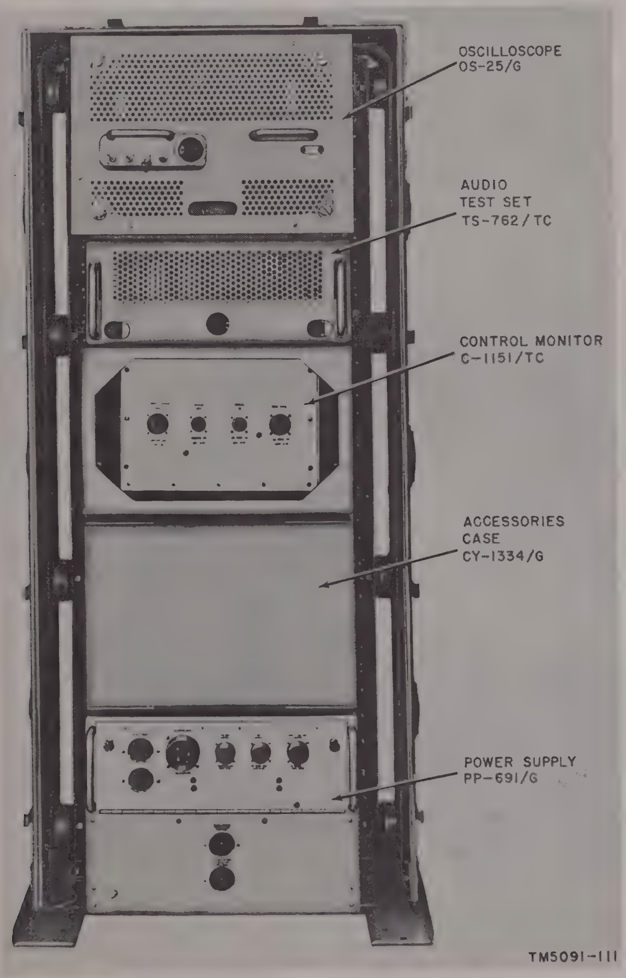

OSCILLOSCOPE OS-25/G
AUDIO TEST SET TS-762/TC
CONTROL MONITOR C-1151/TC
ACCESSORIES CASE CY-1334/G
POWER SUPPLY PP-691/G
TM5091-111

Figure 11. Multiplexer Group AN/TCA-1, test rack, rear view.

21. Description of Control Monitor C–1151/TC

Control Monitor C–1151/TC (fig. 10 and 11) is mounted below the test set and includes the telephone handset and four push-button switches connecting the test pair of leads with the test set or with the telephone handset. The RING switch, located below the four push-button switches, works with the selector switch on any individual modem, and with the four push-button switches to ring any of the wire lines at the far end of the radio-relay system. The telephone handset is stored in a small compartment at the lower right corner of the panel when it is not in use. A cradle is provided alongside this compartment to mount the handset when it is in constant use. A .1-ampere fuse for the microphone current supply is mounted on the front panel below the RING switch. At the rear of the unit is an input power connector, a signal output connector, a signal input connector, and a TEST PAIR connector.

22. Description of Accessories Case CY–1334/G
(fig. 12)

Accessories Case CY–1334/G is a drawer compartment in the test rack. The case provides storage space for the following miscellaneous small parts or tools.

a. One tube puller for a seven-pin miniature tube.

b. One tube puller for a nine-pin miniature tube.

c. One pin straightener for a seven-pin miniature tube.

d. One pin straightener for a nine-pin miniature tube.

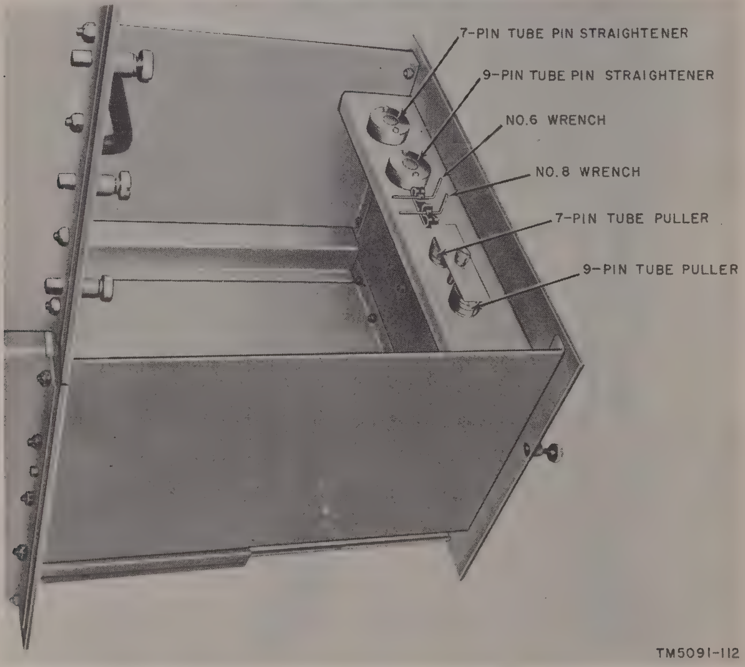


Figure 12. Accessories Case CY–1334/G.

e. One No. 6 Allen-head (socket head), L-type screw wrench.

f. One No. 8 Allen-head (socket head), L-type screw wrench.

23. Description of Power Supply PP–691/G
(fig. 10 and 11)

a. Power Supply PP–691/G is mounted at the bottom of the test rack. It is the main B+ power supply for the multiplexer rack and provides +250 volts direct current (dc) with a total capacity of 1.6 amperes. The power supply acts as the main a-c power input chassis and contains the main and B+ circuit breakers for the entire multiplexer group.

b. The following components are located on the power supply front panel.

(1) A double circuit breaker for the filament supply.

(2) Two 5-ampere fuses.

(3) A filament power indicator lamp.

(4) A voltmeter for measuring the 115-volt a-c line voltage.

(5) A B+ power indicator lamp.

(6) A circuit breaker for the B+ supply.

(7) Two convenience outlets.

c. The following components are located on the rear of the unit:

(1) Two convenience outlets.

(2) An AC POWER INPUT connector.

(3) A B+ output connector.

(4) A B+ and 115-volt a-c connector.

(5) Three 115-volt a-c output connectors.

24. Minor Components

In addition to components mounted in the multiplexer and test racks, the multiplexer set contains the following minor components (par. 25 through 27):

a. Voltage Regulator CN–236/G.

b. Switch Box SA–357/G.

c. Electrical Connector Assembly J–535/G (modem test extension).

25. Description of Voltage Regulator CN–236/G
(fig. 13)

Voltage Regulator CN–236/G is a separately housed component located within 15 feet of the two mounting racks. It is an electromechanically controlled voltage regulator that delivers a constant output independent of line voltage or load current. The front panel controls, indicators, and connectors include: two circuit breakers, a power indicator lamp, three fuses, two screw-driver potentiometer adjustments, and three power connectors. The a-c input power is provided from Switch Box SA–357/G; the 115-volt a-c output power is fed to Power Supply PP–691/G.

26. Description of Switch Box SA–357/G
(fig. 14)

The switch box is individually housed and connects either a 115- or 230-volt a-c power source to the voltage regulator of the multiplexer group. The front of the box contains two male connectors, each of which can be connected to a source of power, such as a gasoline-driven generator or a commercial power source and a toggle switch selecting one of the two power sources that are used by the multiplexer group. Two output connectors are located on the side of the box. At one end of the switch box is a terminal screw and wing nut ground connector that must be connected to a good earth ground through a ground rod, thereby grounding the operating equipment. The switch box should not be located more than 150 feet from the voltage regulator.

27. Description of Electrical Connector Assembly J–535/G
(fig. 15)

Electrical Connector Assembly J–535/G (modem test extension) is an accessory used in making electrical connections between the plug at the rear of the modem and the mating plug in the mounting rack. It applies the necessary power to the modem when the modem has been removed from the rack for servicing. During operation the modem test extension is stored in Accessories Case CY–1334/G.

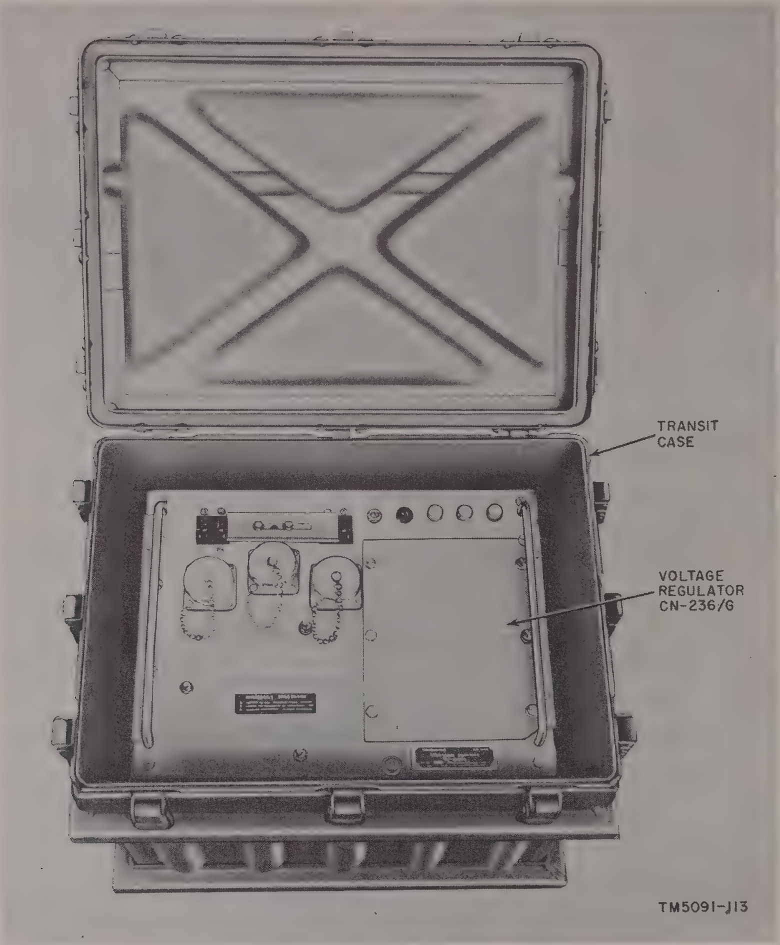


Figure 13. Voltage Regulator CN–236/G.

28. Description of Chest CY–250/U
(fig. 16)

Chest CY–250/U is an olive drab, wooden transit case used for shipping and storing the spare parts, accessories, and cables of the multiplexer group. It is 27 inches long, 21-¼ inches wide, and 20 inches high over-all, and has an adjustable height tray. Two chests are provided for the multiplexer group; they are stenciled "Case 1" and "Case 2". Refer to paragraph 8 for the contents of each case.

29. Description of Cables
(fig. 17 and 18)

a. Cable Reel RC–405/TR and Electrical Power Cable Assembly CX–2440/U. Electrical Power Cable Assembly CX–2440/U (150 ft 0 in.) connects the output of the switch box to the voltage regulator. Cable Reel RC–405/TR is used to store the 150 feet of the cable assembly. The power cable assembly is a three-conductor (No. 16) cable, with a type AN 3106A–32–2P connector at one end and a type AN 3106A–32–2S connector at the other end.

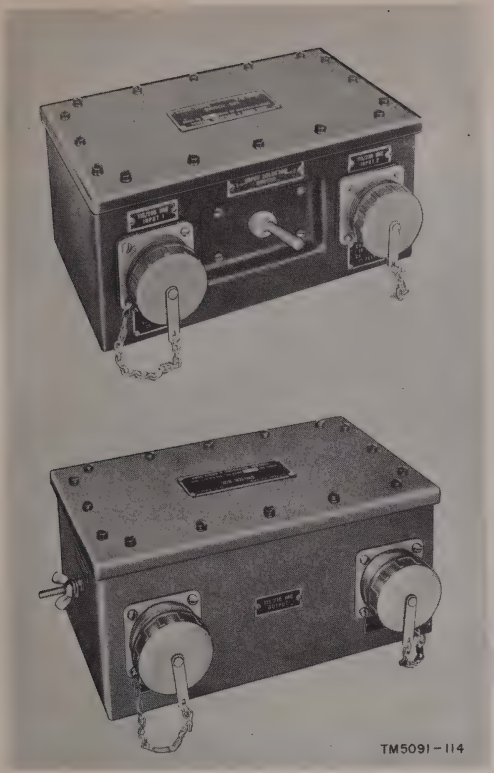


Figure 14. Switch Box SA–357/G, front and rear views.

b. Cord CG–409C/U. Four Cords CG–409C/U (25 ft 0 in.) are supplied with each Multiplexer Group AN/TCA–1. Each one is composed of a Radio Frequency Cable RG–58C/U with a Radio Frequency Plug UG–88/U connector at each end. The table below lists the cable connections for these four cords:

Connect from video restorer connector	Connect to suitable transmission system connector
INPUT FROM EASTFACING REC	VIDEO OUT
OUTPUT TO EASTFACING XMTR	VIDEO IN
INPUT FROM WESTFACING REC	VIDEO OUT
OUTPUT TO WESTFACING XMTR	VIDEO IN

c. Radio-frequency Cable Assembly CG–1040A/U. Two Radio-frequency Cable Assemblies CG–1040A/U (15 ft 3 in.) are supplied with each Multiplexer Group AN/TCA–1. Each cable assembly is composed of RF Cable RG–62A/U with a Plug UG–260/U at each end. The two cable assemblies interconnect Pulse Form Restorer TD–68/G and Oscilloscope OS–25/G.

d. Electrical Power Cable Assembly CX–2272/U. Electrical Power Cable Assembly CX–2272/U (3 ft 5 in.) is a two-conductor (No. 16) cable assembly that interconnects Audio Test Set TS–762/TC and Control Monitor C–1151/TC. It has a type AN 3106B–14S–9S connector at one end and a type AN 3106B–14S–9P connector at the other end.

e. Electrical Power Cable Assembly CX–2273/U. Electrical Power Cable Assembly CX–2273/U (10 ft 4 in.) is a six-conductor (No. 16) cable assembly that interconnects Control Monitor C–1151/TC and Multiplexer Subassembly MX–1442/TC. It has a type AN 3106B–20–7P connector at one end and a type AN 3106B–20–7S connector at the other end.

f. Electrical Power Cable Assembly CX–2275/U. Electrical Power Cable Assembly CX–2275/U (8 ft 4 in.) is a three-conductor (No. 16) cable assembly that supplies +250 volts from Power Supply PP–691/G to Multiplexer Subassembly MX–1442/TC. It has

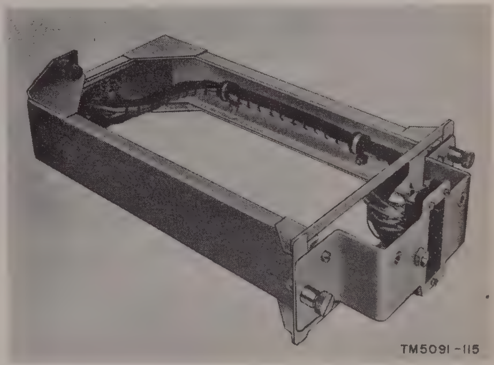


Figure 15. Electrical Connector Assembly J–535/G.

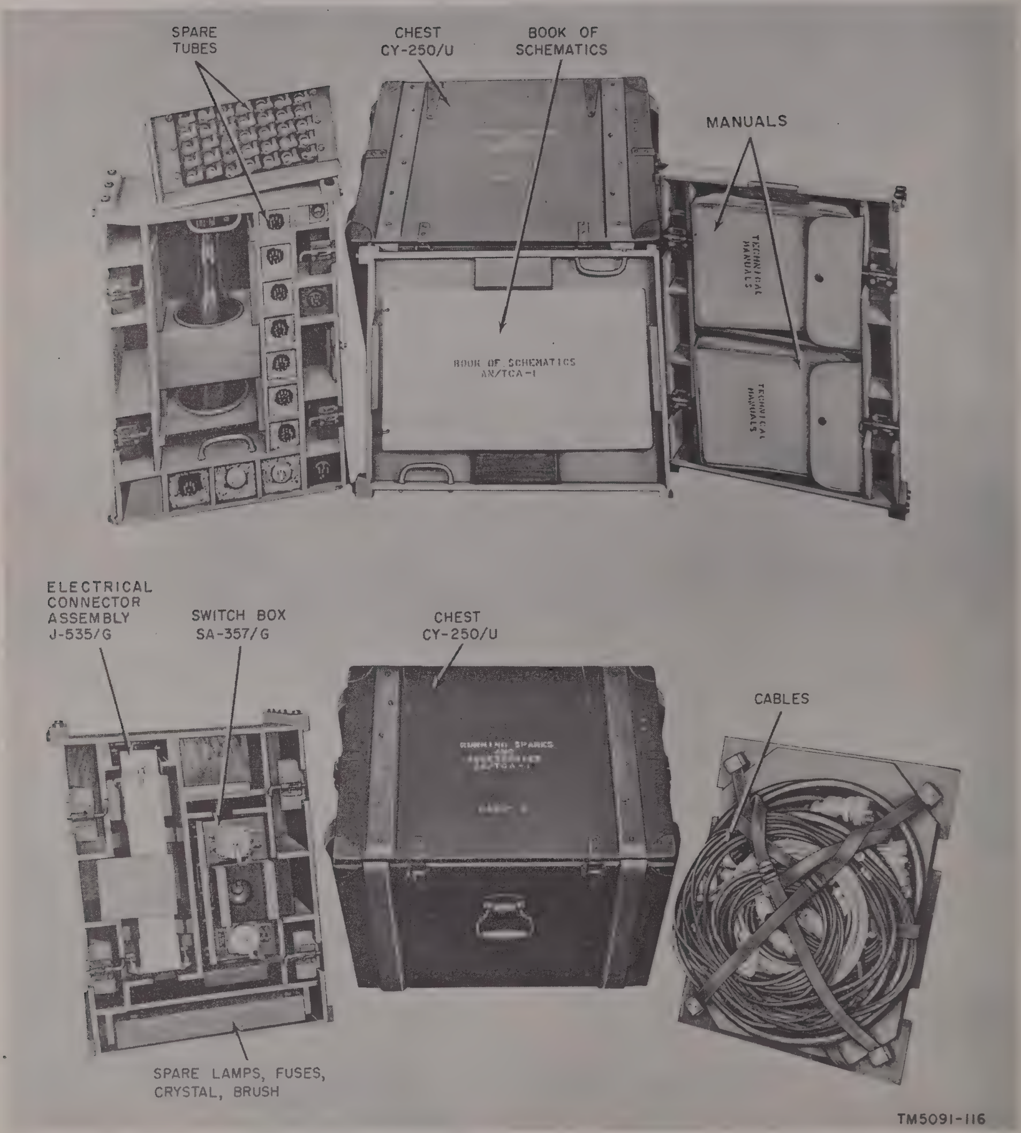

SPARE TUBES
CHEST CY-250/U
BOOK OF SCHEMATICS
MANUALS
TECHNICAL MANUALS
TECHNICAL MANUALS
BOOK OF SCHEMATICS AN/TCA-1
ELECTRICAL CONNECTOR ASSEMBLY J-535/G
SWITCH BOX SA-357/G
CHEST CY-250/U
CABLES
SPARE LAMPS, FUSES, CRYSTAL, BRUSH
TM5091-116

Figure 16. Spare Parts Case 1 and Case 2.

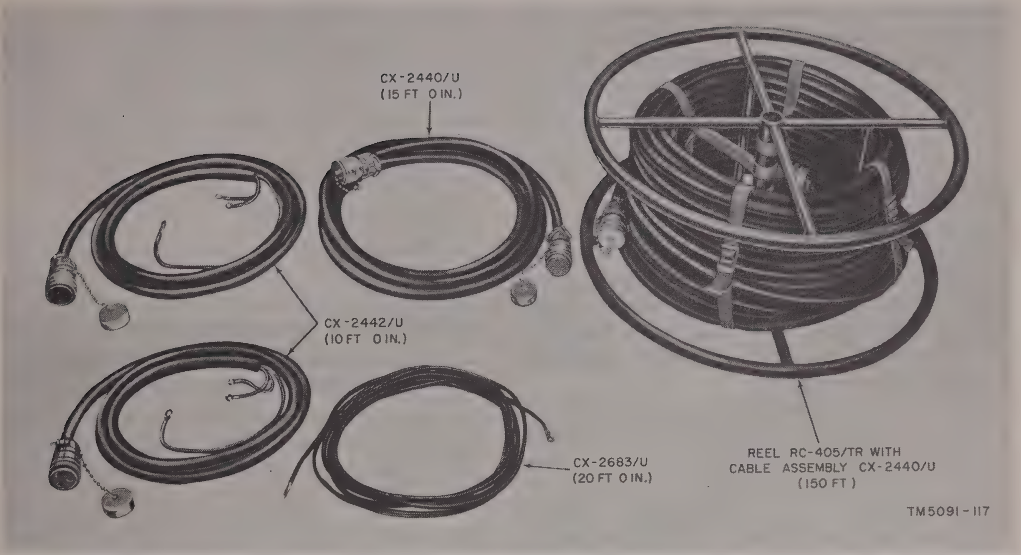


Figure 17. Main power cables.

a type AN 3106B–18–5P connector at one end and a type AN 3106B–18–5S connector at the other end.

g. Electrical Power Cable Assembly CX–2276/U. Electrical Power Cable Assembly CX–2276/U (6 ft 4 in.) is a four-conductor (No. 16) cable assembly that supplies 115 volts ac and +250 volts from Power Supply PP–691/G to Control Monitor C–1151/TC. It has a type AN 3106B–20–4P connector at one end and a type AN 3106B–20–4S connector at the other end.

h. Electrical Power Cable Assembly CX–2277/U. Cable Assembly CX–2277/U (8 ft 4 in.) is a four-conductor (No. 12) cable assembly that supplies 115 volts ac from Power Supply PP–691/G to Multiplexer Subassembly MX–1442/TC. It has a type AN 3106B–18–10P connector at one end and a type AN 3106B–18–10S connector at the other end.

i. Electrical Power Cable Assembly CX–2440/U. Electrical Power Cable Assembly CX–2440/U (15 ft 0 in.) is a three-conductor (No. 6) cable assembly that connects Power Supply PP–691/G with Voltage Regulator CN–236/G. It has a type AN 3106A–32–2S at one end and a type AN 3106A–32–2P connector at the other end.

j. Electrical Power Cable Assembly CX–2441/U. Two Electrical Power Cable Assemblies CX–2441/U (8 ft 5 in.) are provided to supply 115-volt a-c power from Power Supply PP–691/G to Audio Test Set TS–762/TC and Oscilloscope OS–25/G. Each three-conductor (No. 14) cable assembly has a Hubbel type No. 7572 connector at one end and a Hubbel type No. 7555 connector on the other end.

k. Electrical Power Cable Assembly CX–2442/U. Two Electrical Power Cable Assemblies CX–2442/U (10 ft 0 in.) are supplied to connect Switch Box SA–357/G with a prime and auxiliary power source. It has a type AN 3106A–32–2S connector at one end and three terminal leads at the other end.

l. Electrical Power Cable Assembly CX–2682/U. Cable Assembly CX–2682/U (3 ft 3 in.) is a two-conductor (No. 16) cable assembly that interconnects Audio Test Set TS–762/TC and Control Monitor C–1151/TC. It has a type AN 3106B–14S–7P connector at one end and a type AN 3106B–14S–7S connector at the other end.

m. Electrical Lead CX–2683/U. Electrical Lead CX–2683/U (20 ft 0 in.) is a one-conductor (No. 6) cable assembly that grounds

Switch Box SA–357/G to Ground Rod MX–148/G (not supplied). One terminal lead (with eyelet) is connected to the terminal stud (and wing nut) on the GROUND side of the switch box and the other terminal lead connects to the ground rod clamp.

30. Running Spares

A group of running spares is supplied with Multiplexer Group AN/TCA–1 and is stored in Spare Parts Cases 1 and 2. Spares are provided for all normally expendable items, such as tubes, pilot lamps, and fuses. Running spares supplied with the equipment are listed in paragraph 8*d* and 8*e*.

31. Electrical Power Requirements

a. Multiplexer Group AN/TCA–1 requires a single-phase a-c input. This can be obtained from any source of power that has voltage and frequency regulations within the following limits:

(1) 115- or 230-volt ac ±10 per cent.

(2) 47.5 to 63 cps.

b. The multiplexer group consumes 1,100 watts.

32. Additional Equipment Required

No additional equipment is necessary to install Multiplexer Group AN/TCA–1 other

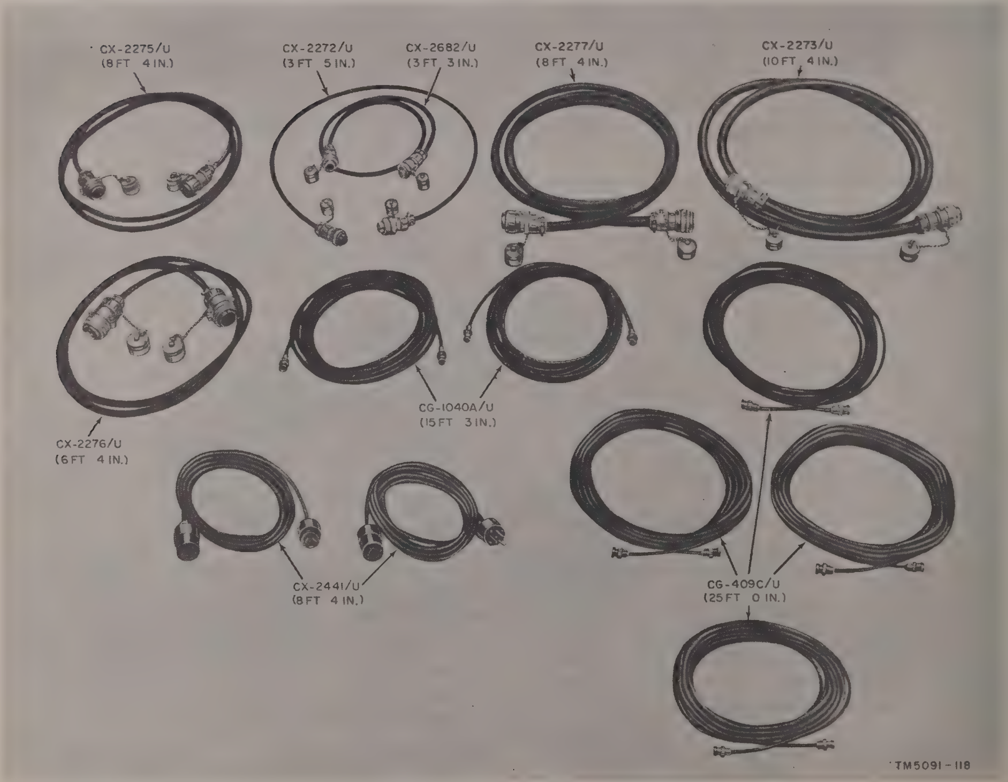

CX-2275/U
(8 FT 4 IN.)
CX-2272/U
(3 FT 5 IN.)
CX-2682/U
(3 FT 3 IN.)
CX-2277/U
(8 FT 4 IN.)
CX-2273/U
(10 FT 4 IN.)
CX-2276/U
(6 FT 4 IN.)
CG-1040A/U
(15 FT 3 IN.)
CX-2441/U
(8 FT 4 IN.)
CG-409C/U
(25 FT 0 IN.)
TM5091-118

Figure 18. Interconnecting power and signal cables.

than ordinary small hand tools and a vacuum tube voltmeter (vtvm). Because the multiplexer group is always operated as part of a communication system, a radio set capable of being modulated over the required bandwidth (such as Radio Set AN/TRC–29) is necessary, in addition to the individual telephone handsets or manual telephone switchboard.

Section III. BASIC PRINCIPLES

33. General

Multiplexer Group AN/TCA–1 provides drop and insert facilities and wave form reshaping at a repeater station. The basic principles of wave form reshaping are described in paragraph 34, and the basic principles of tdm, ppm, and the combination of the two which results in a ppm-tdm train are described in paragraphs 35, 36, and 37.

34. Wave Form Reshaping
(fig. 19)

When the width, amplitude, or rise and decay time of a pulse has deteriorated, and its original shape is desired, consider the following:

a. Width. To obtain the desired output pulse width, it is necessary to narrow or widen the received pulses (A, fig. 19). This can be done by using a differentiator circuit or by slicing the received pulse at a selected amplitude.

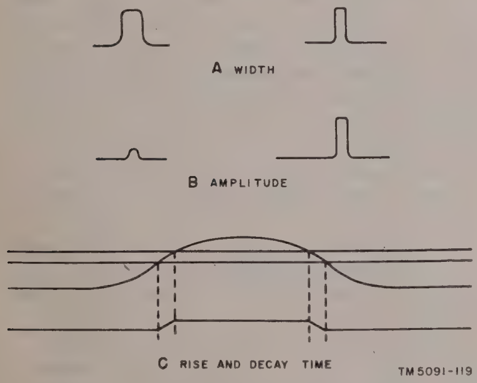


Figure 19. Principle of wave form reshaping.

b. Amplitude. The desired amplitude is obtained by providing sufficient gain so that the incoming signal will be amplified to the correct level (B, fig. 19). The use of clipping circuits limits the output to the desired amplitude.

c. Rise and Decay Time. Multihop transmission reduces the bandwidth of the transmitted signal and therefore increases the rise and decay time. To restore the original characteristics, clipping and slicing operations are performed on the pulses. Clipping is an operation where the top or bottom of a pulse is clipped (C, fig. 19). Slicing is an operation where a narrow (10 per cent) slice of the pulse (in amplitude) is taken out of the pulse.

35. Principle of Time-division Multiplexing

a. General. The simultaneous transmission and reception of many channels over a single line is called multiplexing. There are two basic methods of multiplexing: frequency multiplexing and time multiplexing. Time multiplexing is the type used in Multiplexer Group AN/TCA–1.

b. Time-division Multiplexing.

(1) In the telephone system, switches S1 and S2 (fig. 20) are synchronized so that when S1 is in position A, S2 is in position A, and, similarly, both are in position B at the same time. If a telephone call is made on telephone line 1, it is completed when the switches are in position A. Similarly, the calls on telephone line 2 are completed when the switches are in position B.

(2) If both lines are in use and the switches are moved slowly back and forth between positions A and B, each

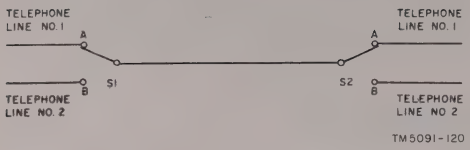


Figure 20. Simple time-division multiplex example.

party loses an appreciable part of the signal. However, as the rate of the switching increases, less and less of the signal is lost. Finally, when the switching rate is high enough (twice the frequency of the highest audio component being transmitted), no information is lost. The human ear can no longer detect the high speed interruption. By this method, instead of transmitting a signal about the instantaneous amplitude of the input wave form, periodic samples of the signal are taken. No information is lost, provided that the sampling rate is high enough. In this way, two conversations can be held over the same line simultaneously. This method of splitting up the time that is used by each telephone is called time division.

(3) This same method of splitting the time can be used with two eight-position rotary switches, if the sampling speed is high enough. In the example shown in figure 21, each of the lines is connected by the transmitting medium only one-eighth of the time. As the switch completes a cycle, each channel is sampled once, but again continuous sound is heard when the sampling rate is high enough. With the proper circuitry, the switch can be closed for as short a period as desired. In the system used in this equipment, the transmission time is broken up into 24 parts, one for each of the voice-frequency channels plus one synchronizing channel, and electronic switching rather than mechanical is used.

36. Principle of Pulse-position Modulation (fig. 22)

a. Pulse-position modulation is a system where the position (or time) of a pulse varies in accordance with the modulation applied to the circuit, figure 22. Curve A, figure 22, is the modulating signal and curve B is the resulting position-modulated series of pulses. The 8-kc base wave sinusoid represents the basic frequency component used in generating the marker and associated channel pulses.

b. As shown in curve B, figure 22, the position of the pulse varies around *zero* reference (the unmodulated position). Viewing curve B from the top downward, the following conditions occur:

(1) With no modulating signal present, the pulse remains on the zero reference line.

(2) With the modulating voltage slightly positive, the pulse is shifted to the right (occurring later in time) of the zero reference line.

(3) With the modulating voltage more positive, the pulse is shifted further to the right (occurring still later in time).

(4) As the modulating voltage decreases toward zero, so then does the distance between the pulse and the zero reference line decrease.

(5) With the modulating voltage negative, the pulse is shifted to the left (occurring earlier in time) in the same manner described in subparagraphs (1) through (4) above.

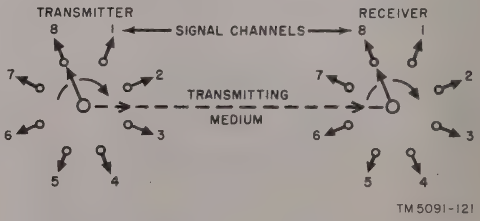


Figure 21. Eight-channel, time-division multiplex example.

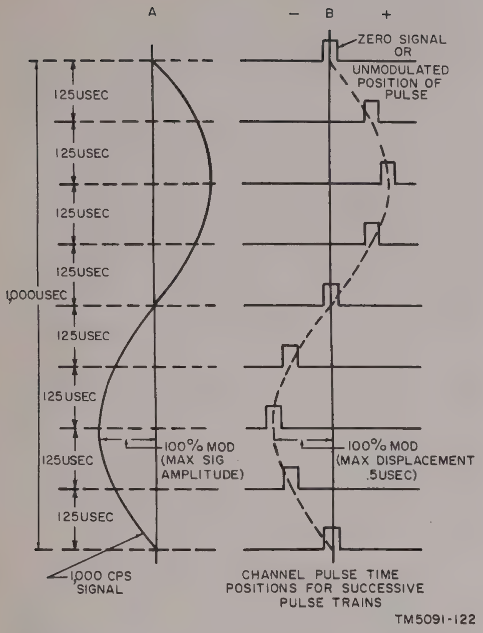

A
– B +
ZERO SIGNAL OR UNMODULATED POSITION OF PULSE
125USEC
125USEC
125USEC
125USEC
1,000USEC
125USEC
125USEC
125USEC
125USEC
100% MOD (MAX SIG AMPLITUDE)
100% MOD (MAX DISPLACEMENT .5USEC)
1,000 CPS SIGNAL
CHANNEL PULSE TIME POSITIONS FOR SUCCESSIVE PULSE TRAINS
TM5091-122

Figure 22. Principle of pulse-position modulation.

c. The amplitude of the modulating voltage will determine the displacement of the pulse, and the frequency of the modulating voltage will determine the speed of displacement. This principle is applied to each pulse in the pulse train.

37. Ppm-tdm System Used in Multiplexer Group

a. In Multiplexer Group AN/TCA–1, ppm is combined with tdm. Each channel pulse displacement is only a small fraction of the total available time. During the remaining portion of time, other modulating pulses are inserted. The total time is divided among the 25 channels and the double marker pulse.

b. B, figure 23, shows a single set of marker pulses used as a reference set for all channels. These marker pulses are distinguished from the other pulses by a double pulse. Each channel pulse then appears in its proper position after the marker pulse. First the channel 1 pulse appears, appropriately displaced in time; then the channel 2 pulse, channel 3, etc., until the channel 23 pulse appears. After the channel 23 pulse, the marker pulse appears again and the cycle is repeated.

c. The maximum displacement of each channel pulse is limited so that they do not run together. Even if the channel 1 pulse is at its maximum right-hand position and the channel 2 pulse at its maximum left-hand position, enough space (guard time) is allowed so that these pulses do not run into each other.

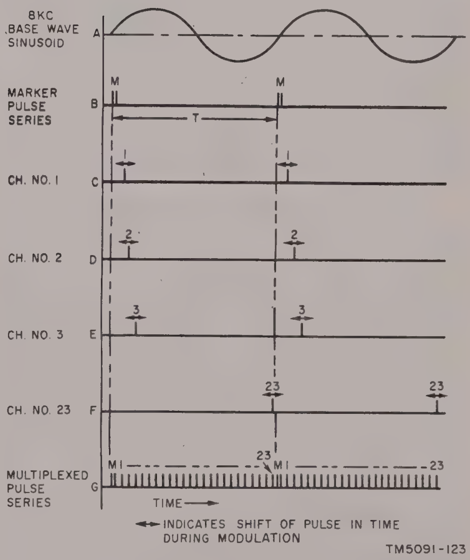

8KC BASE WAVE SINUSOID
A
MARKER PULSE SERIES
B
M
M
T
CH. NO. 1
C
1
1
CH. NO. 2
D
2
2
CH. NO. 3
E
3
3
CH. NO. 23
F
23
23
MULTIPLEXED PULSE SERIES
G
M I
23
M I
23
TIME
INDICATES SHIFT OF PULSE IN TIME DURING MODULATION
TM5091-123

Figure 23. Principle of time-division multiplexing.

38. General

The multiplexer group can be divided into six functional circuits. These six functional circuits are listed below.

a. Reshaping circuit (par. 39).

b. Demultiplexing and demodulating circuit (par. 40).

c. Modulating and multiplexing circuit (par. 41).

d. Blanking and insert circuit (par. 42).

e. Power supplies circuit (par. 43).

f. Test and measurement circuit (par. 44).

g. Remote keying circuit (par. 45).

Note. The functional circuits of Pulse Form Restorer TD–68/G (subpar. *a* through *d* above) are all duplicated, one for each direction of transmission.

39. Reshaping Circuit

a. Function. The reshaping circuit restores the 23- or 45-channel pulse train to a standard waveshape, for both directions of transmission.

b. Description. The reshaping circuit accepts a pulse train from the radio set receiver and reshapes it to a standard waveshape. The reshaper circuit corrects the received pulse train for amplitude (amplifier and limiter circuits), width (differentiator circuit), and rise and decay times (slicing and clipping circuits). The desired output is obtained by passing the pulse with the desired characteristics through a 1-megacycle (mc) low-pass filter. The output of the filter is fed to the transmitter.

40. Demultiplexing and Demodulating Circuit

a. Function. The demultiplexing and demodulating circuit accepts a single pulse train from the suitable transmission system and removes the first eight channel pulses, demultiplexes them, demodulates them, and then feeds them to the lines.

b. Description. The demultiplexer section of the pulse form restorer receives the pulse train and, with the delay line, furnishes eight successively delayed unblocking gates to the modem demodulators. In addition, the demultiplexer section reshapes and amplifies the channel pulses, and feeds them to the eight modems. The gate output of the delay line is used to select the appropriate channel pulse from the complete pulse train by unblocking the particular modem demodulator section. In a modem, the channel pulse modulation is converted to pulse-width modulation, and the audio information is extracted by means of a low-pass audio filter. The output of the filter is then amplified and transmitted over the line.

41. Modulating and Multiplexing Circuit

a. Function. The modulating and multiplexing circuit accepts the eight independent v-f signals from the lines and converts them into the ppm channel pulses. These pulses then are fed to the blanking and insert circuit.

b. Description. The multiplexer section of the video restorer, with the delay line, furnishes eight successively delayed time references to the modem modulators. Each modem modulator generates a channel pulse in the allotted time position. The time of occurrence of these channel pulses is either advanced or retarded in the modems to correspond to the amplitude of the audio information impressed on the modems from the lines. The eight individually modulated channel pulses then are combined in the multiplexer section of the video restorer, and the signal is fed to the blanking and insert circuit.

42. Blanking and Insert Circuit

a. Function. The blanking and insert circuit blanks out the old channel pulse and inserts the locally generated pulse in its place in the pulse train.

b. Description. The blanking gates from the delay line are amplified and reshaped in the blanking circuit and then used to blank out channel pulses one through eight. It then accepts the locally generated combined channel pulses from the multiplexer section and combines them with the blanked main pulse train (from which the eight channels were originally blanked) to form a complete new pulse train. This complete pulse train is then fed to the reshaping circuit for additional reshaping before transmission.

43. Power Supplies Circuit

a. Function. The power circuit supplies the necessary operating voltages to the various sections of the multiplexer group from the primary power source.

b. Description. The power circuit consists of the multiplexer subassembly, the power supply (B+ supply), the voltage regulator, necessary fuses, switches, switch box, and cables. Filament power to all components is provided by the filament supply. Separate B+ fuses for the video restorer are contained on the video restorer front panel. The fuses on the filament supply are divided into two sections: one filament fuse pair and two B+ fuses for the left column of modems, and one filament fuse pair and two B+ fuses for the right column. A-c power is brought into the power supply on the test equipment rack from the switch box (through the voltage regulator). The switch box selects one of two primary sources of a-c power that is to be used for operation. The power supply provides B+ for all the units on the multiplexer rack. Connections are made from the lower rear of the test equipment rack to all other chassis that require a-c power, such as the oscilloscope, test set, mounting rack, and the various utility (convenience) outlets. The main power switches are on the power supply, which also has a meter for measuring the line voltage. All convenience outlets have their own fuse pair on the power supply so that short circuits in any auxiliary equipment do not disrupt the operation of the multiplexer group itself.

44. Test and Measurement Circuit

a. Function. The test and measurement circuit provides the facilities for complete maintenance of the multiplexer group. This circuit includes test and measurement facilities, order-wire facilities, and an alarm system.

b. Description.

(1) *Test and measurement facilities.* The test and measurement facilities consist of test pin jacks on the front panels of the video restorer and modems, and the test equipment that is mounted in the test rack. The test equipment includes the oscilloscope, audio test set, and control monitor (par. 19 through 21). All the necessary audio tests are set up by individual test switches on the modems and the control monitor test switch. Besides performing all the functions of a laboratory test instrument, the oscilloscope contains special synchronizing and timing-pip circuits that permit rapid alignment and video adjustment of the multiplexer group.

(2) *Order-wire facilities.* The order-wire system provides a channel (channel 1) of the multiplexer group for communication between the operators of the various stations for instructions, testing, trouble shooting, and other official business. When the NORMAL push button on the control monitor is depressed, the telephone handset is connected to channel 1 on a two-wire basis. This enables the station operator to communicate with operators at other stations who are similarly tied across channel 1 (if channel 1 is in two-wire position). The order-wire system also includes a local bell to indicate when the station is called and a ring switch for ringing on this channel. If the order-wire channel fails, use any other preselected channel. With the preselected channel set on a two-wire basis, turn the appropriate channel modem selector switch to either SR or RR, and depress the TEL SET button on the control monitor.

(3) *Alarm circuit.* The alarm circuit indicates an improper input to the multiplexer group or improper operation of the demultiplexer section. The

alarm system is controlled by the train of pulses that is received at the multiplexer group. It operates on the failure of any of the tubes in the positive pulse train section output, input of any signal less than .1 volt peak, receipt of a high noise input, and failure in the demultiplexer circuit. However, the failure of a single modem or group of modems does not cause the alarm to be activated. Operation of the alarm causes a red warning light on Multiplexer Subassembly MX–1442/TC to glow and an alarm buzzer to sound. When the alarm circuit is activated, the pulse train from the receiver is applied directly to the transmitter.

45. Remote Keying Circuit

a. Function. The remote keying facility permits two types of remote keying operation on either or both channel 1 and channel 2.

(1) An operator at a multiplexer location can control a vhf station that is located near another multiplexer location.

(2) A vhf mobile unit can *talk through* a vhf station at a multiplexer location, through the microwave system (Radio Set AN/TRC–29) to another multiplexer location, then through another vhf station to a second mobile unit.

Note. A multiplexer location is either an AN/TCC–13 terminal, an AN/TRA–10 repeater, or an AN/TCA–1 repeater; all these act similarly for remote keying operation.

b. Description (fig. 24). For the east operator to talk through the vhf transmitter at the west terminal, he closes his remote keying switch, which causes the following:

(1) Because this switch is connected to the REMOTE KEYING IN binding posts at the restorer group, it short-circuits these binding posts. This

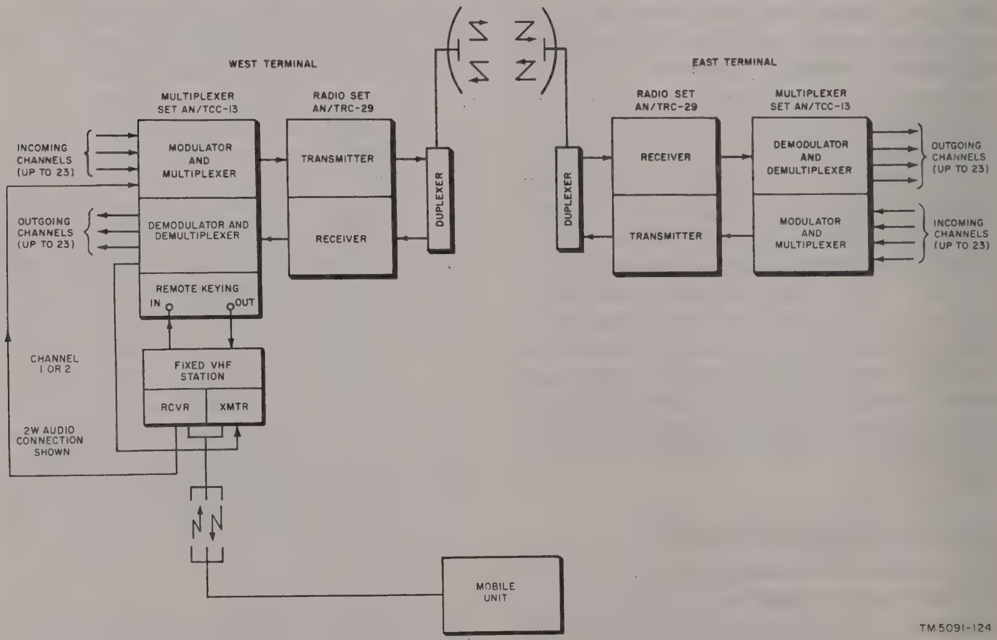

WEST TERMINAL
MULTIPLEXER SET AN/TCC-13
RADIO SET AN/TRC-29
INCOMING CHANNELS (UP TO 23)
MODULATOR AND MULTIPLEXER
TRANSMITTER
DUPLEXER
OUTGOING CHANNELS (UP TO 23)
DEMODULATOR AND DEMULTIPLEXER
RECEIVER
REMOTE KEYING
IN
OUT
CHANNEL 1 OR 2
FIXED VHF STATION
RCVR
XMTR
2W AUDIO CONNECTION SHOWN
MOBILE UNIT
EAST TERMINAL
RADIO SET AN/TRC-29
MULTIPLEXER SET AN/TCC-13
DUPLEXER
RECEIVER
DEMODULATOR AND DEMULTIPLEXER
OUTGOING CHANNELS (UP TO 23)
TRANSMITTER
MODULATOR AND MULTIPLEXER
INCOMING CHANNELS (UP TO 23)
TM 5091-124

Figure 24. Remote keying operation between multiplexer location and mobile unit, block diagram.

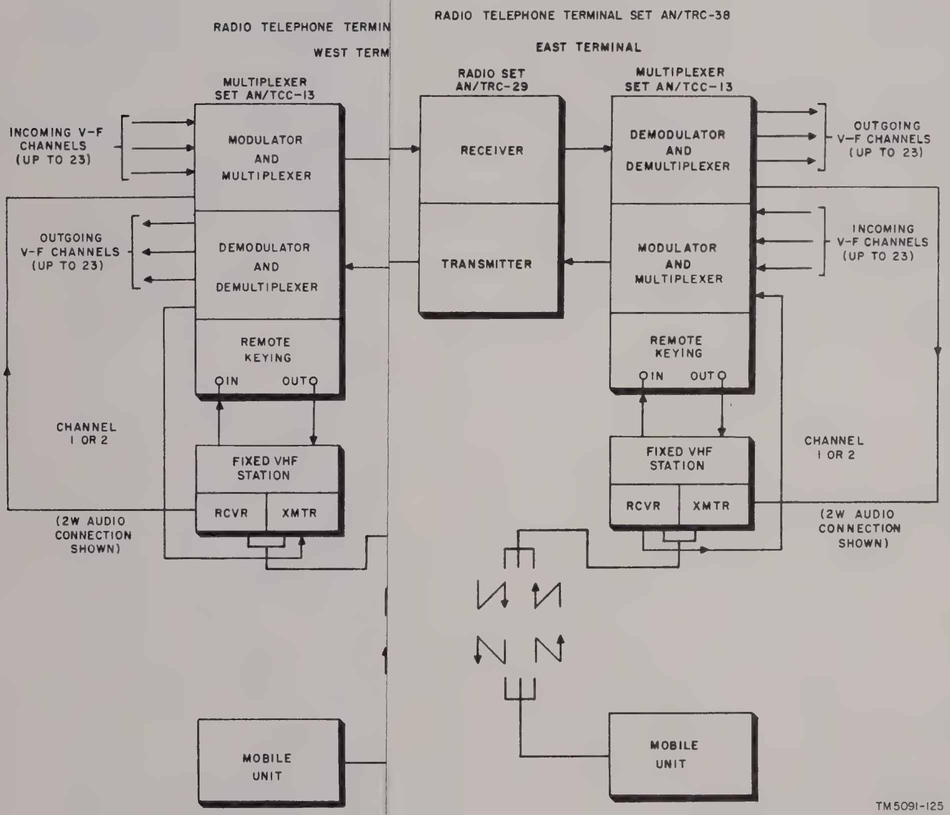

RADIO TELEPHONE TERMIN
WEST TERM
RADIO TELEPHONE TERMINAL SET AN/TRC-38
EAST TERMINAL
MULTIPLEXER SET AN/TCC-13
RADIO SET AN/TRC-29
MULTIPLEXER SET AN/TCC-13
INCOMING V-F CHANNELS (UP TO 23)
MODULATOR AND MULTIPLEXER
RECEIVER
DEMODULATOR AND DEMULTIPLEXER
OUTGOING V-F CHANNELS (UP TO 23)
OUTGOING V-F CHANNELS (UP TO 23)
DEMODULATOR AND DEMULTIPLEXER
TRANSMITTER
MODULATOR AND MULTIPLEXER
INCOMING V-F CHANNELS (UP TO 23)
REMOTE KEYING
IN
OUT
REMOTE KEYING
IN
OUT
CHANNEL 1 OR 2
FIXED VHF STATION
RCVR
XMTR
(2W AUDIO CONNECTION SHOWN)
FIXED VHF STATION
RCVR
XMTR
CHANNEL 1 OR 2
(2W AUDIO CONNECTION SHOWN)
MOBILE UNIT
MOBILE UNIT
TM5091-125

Figure 25. Remote keying operation between two mobile units, block diagram.

alarm system is controlled by the train of pulses that is received at the multiplexer group. It operates on the failure of any of the tubes in the positive pulse train section output, input of any signal less than .1 volt peak, receipt of a high noise input, and failure in the demultiplexer circuit. However, the failure of a single modem or group of modems does not cause the alarm to be activated. Operation of the alarm causes a red warning light on Multiplexer Subassembly MX–1442/TC to glow and an alarm buzzer to sound. When the alarm circuit is activated, the pulse train from the receiver is applied directly to the transmitter.

45. Remote Keying Circuit

a. Function. The remote keying facility permits two types of remote keying operation on either or both channel 1 and channel 2.

(1) An operator at a multiplexer location can control a vhf station that is located near another multiplexer location.

(2) A vhf mobile unit can *talk through* a vhf station at a multiplexer location, through the microwave system (Radio Set AN/TRC–29) to another multiplexer location, then through another vhf station to a second mobile unit.

Note. A multiplexer location is either an AN/TCC–13 terminal, an AN/TRA–10 repeater, or an AN/TCA–1 repeater; all these act similarly for remote keying operation.

b. Description (fig. 24). For the east operator to talk through the vhf transmitter at the west terminal, he closes his remote keying switch, which causes the following:

(1) Because this switch is connected to the REMOTE KEYING IN binding posts at the restorer group, it short-circuits these binding posts. This

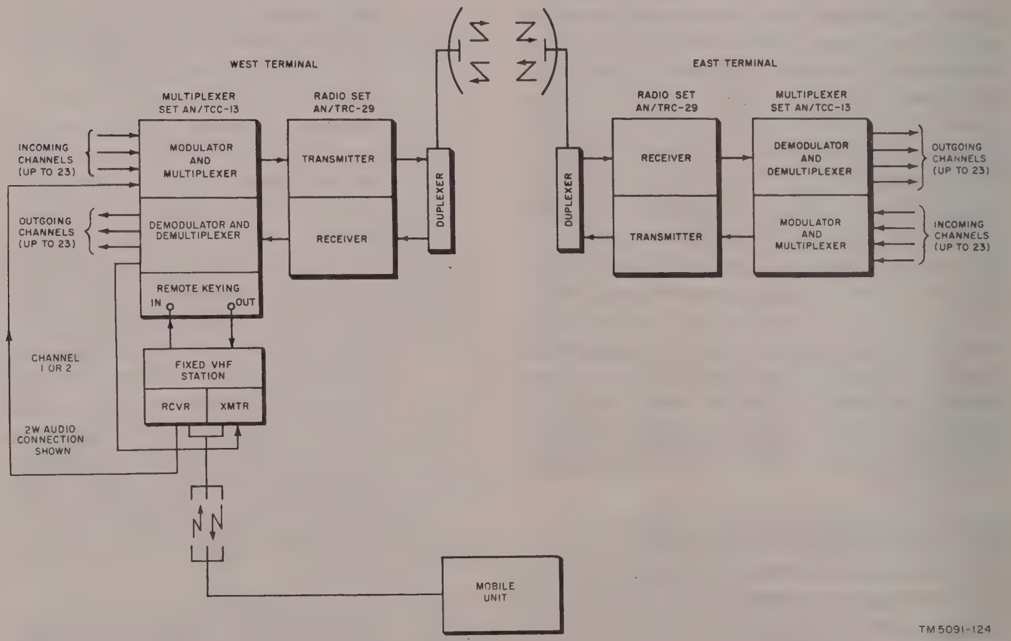

WEST TERMINAL
MULTIPLEXER SET AN/TCC-13
RADIO SET AN/TRC-29
INCOMING CHANNELS (UP TO 23)
MODULATOR AND MULTIPLEXER
TRANSMITTER
OUTGOING CHANNELS (UP TO 23)
DEMODULATOR AND DEMULTIPLEXER
RECEIVER
DUPLEXER
REMOTE KEYING
IN
OUT
CHANNEL 1 OR 2
FIXED VHF STATION
RCVR
XMTR
2W AUDIO CONNECTION SHOWN
MOBILE UNIT
EAST TERMINAL
RADIO SET AN/TRC-29
MULTIPLEXER SET AN/TCC-13
DUPLEXER
RECEIVER
DEMODULATOR AND DEMULTIPLEXER
OUTGOING CHANNELS (UP TO 23)
TRANSMITTER
MODULATOR AND MULTIPLEXER
INCOMING CHANNELS (UP TO 23)
TM 5091-124

Figure 24. Remote keying operation between multiplexer location and mobile unit, block diagram.

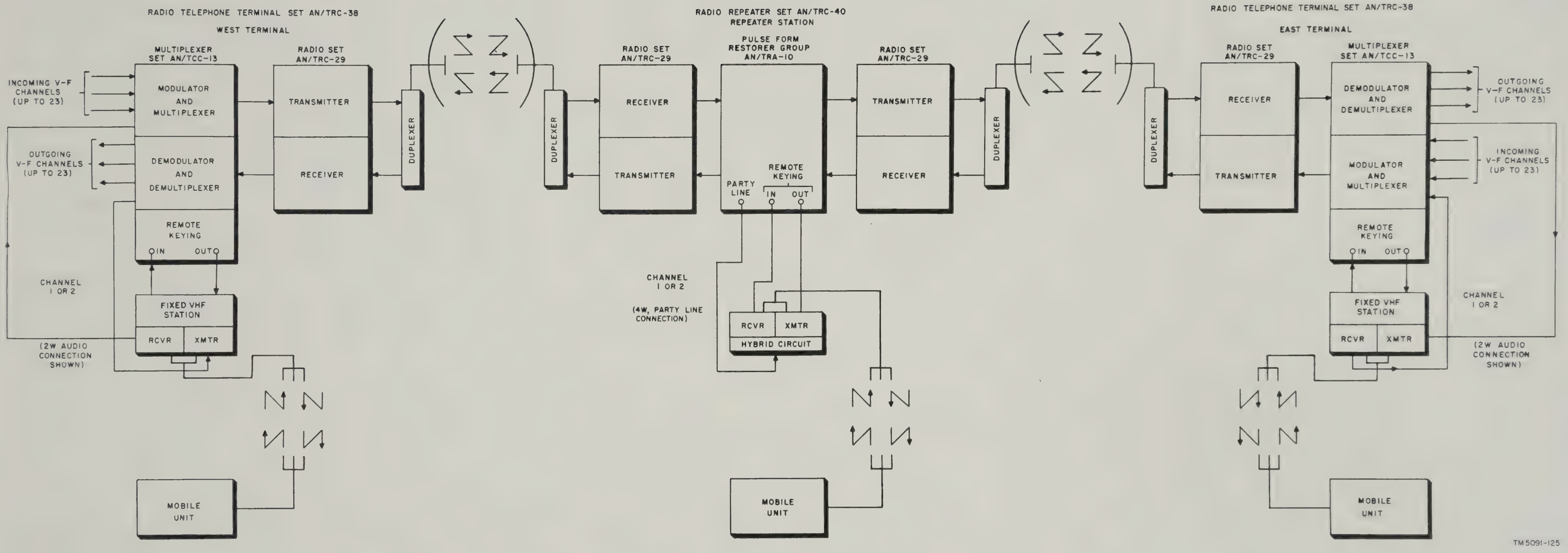

RADIO TELEPHONE TERMINAL SET AN/TRC-38
WEST TERMINAL
MULTIPLEXER SET AN/TCC-13
RADIO SET AN/TRC-29
INCOMING V-F CHANNELS (UP TO 23)
MODULATOR AND MULTIPLEXER
TRANSMITTER
OUTGOING V-F CHANNELS (UP TO 23)
DEMODULATOR AND DEMULTIPLEXER
RECEIVER
DUPLEXER
REMOTE KEYING
IN
OUT
CHANNEL 1 OR 2
FIXED VHF STATION
RCVR
XMTR
(2W AUDIO CONNECTION SHOWN)
MOBILE UNIT
RADIO REPEATER SET AN/TRC-40
REPEATER STATION
RADIO SET AN/TRC-29
PULSE FORM RESTORER GROUP AN/TRA-10
RADIO SET AN/TRC-29
DUPLEXER
RECEIVER
TRANSMITTER
TRANSMITTER
RECEIVER
PARTY LINE
REMOTE KEYING
IN
OUT
DUPLEXER
CHANNEL 1 OR 2
(4W, PARTY LINE CONNECTION)
RCVR
XMTR
HYBRID CIRCUIT
MOBILE UNIT
RADIO TELEPHONE TERMINAL SET AN/TRC-38
EAST TERMINAL
RADIO SET AN/TRC-29
MULTIPLEXER SET AN/TCC-13
DUPLEXER
RECEIVER
DEMODULATOR AND DEMULTIPLEXER
OUTGOING V-F CHANNELS (UP TO 23)
TRANSMITTER
MODULATOR AND MULTIPLEXER
INCOMING V-F CHANNELS (UP TO 23)
REMOTE KEYING
IN
OUT
FIXED VHF STATION
CHANNEL 1 OR 2
RCVR
XMTR
(2W AUDIO CONNECTION SHOWN)
MOBILE UNIT
TM5091-125

Figure 25. Remote keying operation between two mobile units, block diagram.

causes the pulse for the given channel to be inserted in the pulse train and sent by Radio Set AN/TRC–29 to the west terminal. This pulse at the west terminal causes a relay to operate which *keys on* the fixed vhf transmitter. Therefore, when the east operator talks, his voice signal is transmitted through the radio-relay system by modulation of the inserted pulse, and modulates the remote fixed vhf station transmitter signal. If the mobile unit is within range of the fixed vhf station transmitter, the vhf signal will be received and heard by the mobile unit operator.

(2) To reply, the mobile unit operator transmits a modulated vhf signal which is picked up by the fixed vhf receiver at the west terminal. The receipt of this signal operates a squelch relay. The contacts of this relay are connected to the REMOTE KEYING IN binding posts of the restorer group. When the squelch relay shorts these contacts, it causes the proper channel pulse to be inserted in the output pulse train; therefore, when the mobile unit operator talks, his speech signal is received by the vhf receiver at the west terminal multiplexer set, where it is connected to the multiplexer set and modulates the inserted pulse. The modulated pulse train is transmitted to the east terminal by the radio-relay system. There it is demultiplexed and demodulated by the east terminal multiplexer set and then fed by the normal binding posts to the original east operator.

(3) To talk from one mobile unit to another by way of two fixed vhf stations at two different multiplexer locations, either mobile unit operator must operate exactly as if he were talking to another mobile unit (fig. 25). The signal is carried through the multiplexer set and radio relay system exactly as described in subparagraphs (1) and (2) above, except that there is a vhf station at both locations.

(4) At a repeater when the local vhf fixed station receives a signal from a mobile unit, the keying and audio signal is fed to both the east and west terminals because the remote keying circuit is always on a party-line basis. Similarly, the fixed vhf transmitter will be keyed on by a signal from either the east or west terminal.

46. Ventilation System

a. Function. The ventilating system keeps the temperature of the components on the multiplexer rack and the oscilloscope from exceeding a safe limit.

b. Description.

(1) The multiplexer rack ventilating system consists of a fan that is mounted in the filament supply and an air filter at the front of the filament supply. *It is important that this filter be cleaned often to prevent the accumulation of dirt throughout the rack with a resulting increase of operating temperature.* A fuse for the fan is mounted on the front panel of the filament supply.

(2) A fan that is mounted on the oscilloscope chassis provides ventilation for the cathode-ray tube and other components of Oscilloscope OS–25/G.

(3) Pulse Form Restorer TD–68/G has a fan mounted on the front panel, which provides ventilation for tubes and other components.

CHAPTER 2
INSTALLATION

Section I. SERVICE UPON RECEIPT OF MULTIPLEXER GROUP AN/TCA–1

47. Siting

a. Multiplexer Group AN/TCA–1 is never used alone, but always as a part of a radio-relay system. The siting problems that are applicable to the associated radio set are always the prime consideration when installing the equipment.

b. The multiplexer group may be located in any place that is convenient to the supplied radio set, the audio input lines, and the power source.

48. Uncrating, Unpacking, and Checking New Equipment

Note. For used or reconditioned equipment, refer to paragraph 52.

a. General. The components of Multiplexer Group AN/TCA–1 may be packed for oversea or domestic shipment. Check the number of crates against the table of components (par. 8) to be sure that all the components have been received.

Caution: Be careful when uncrating, unpacking, and handling the equipment; it is easily damaged. If it becomes damaged or exposed, a complete overhaul may be required, or the equipment may be rendered useless.

b. Step-by-step Instructions for Uncrating Equipment Rack Crates (fig. 26).

(1) Place equipment rack packing crates as near the operating position as convenient.

(2) Remove the nails from the top and one end of the wooden crate with a nail puller. Do not *pry* off the top; the equipment may be damaged.

(3) Remove the nails from the remaining sides of the crate with a nail puller.

(4) Cut the barrier and remove the corrugated cover.

(5) Remove the end fillers and desiccant.

(6) Cut each of the three strappings.

(7) Use the carrying handles (fig. 4) to remove the cases. These cases weigh as much as 535 pounds; seven men may be required to remove each case.

(8) Place the cases at the desired locations.

(9) Inspect the equipment for possible damage incurred during shipment.

(10) Check the contents of each packing case against the master packing list.

c. Step-by-step Instructions for Unpacking Small Crates (fig. 27).

(1) Place the small packing crates as near the operating position as convenient.

(2) Cut and fold back the steel straps.

(3) Remove the nails from the top and from one side of the crate with a nail puller. Do not *pry* off the top; the equipment may be damaged.

(4) Remove the nails from the remaining sides of the crate with a nail puller.

(5) Open the outer moistureproof barrier.

(6) Remove the outer corrugated carton.

(7) Open the inner moisture-vaporproof barrier.

49. General Installation

a. Other than the initial uncrating, which requires seven men to lift the transit cases from the packing crates, one man who is

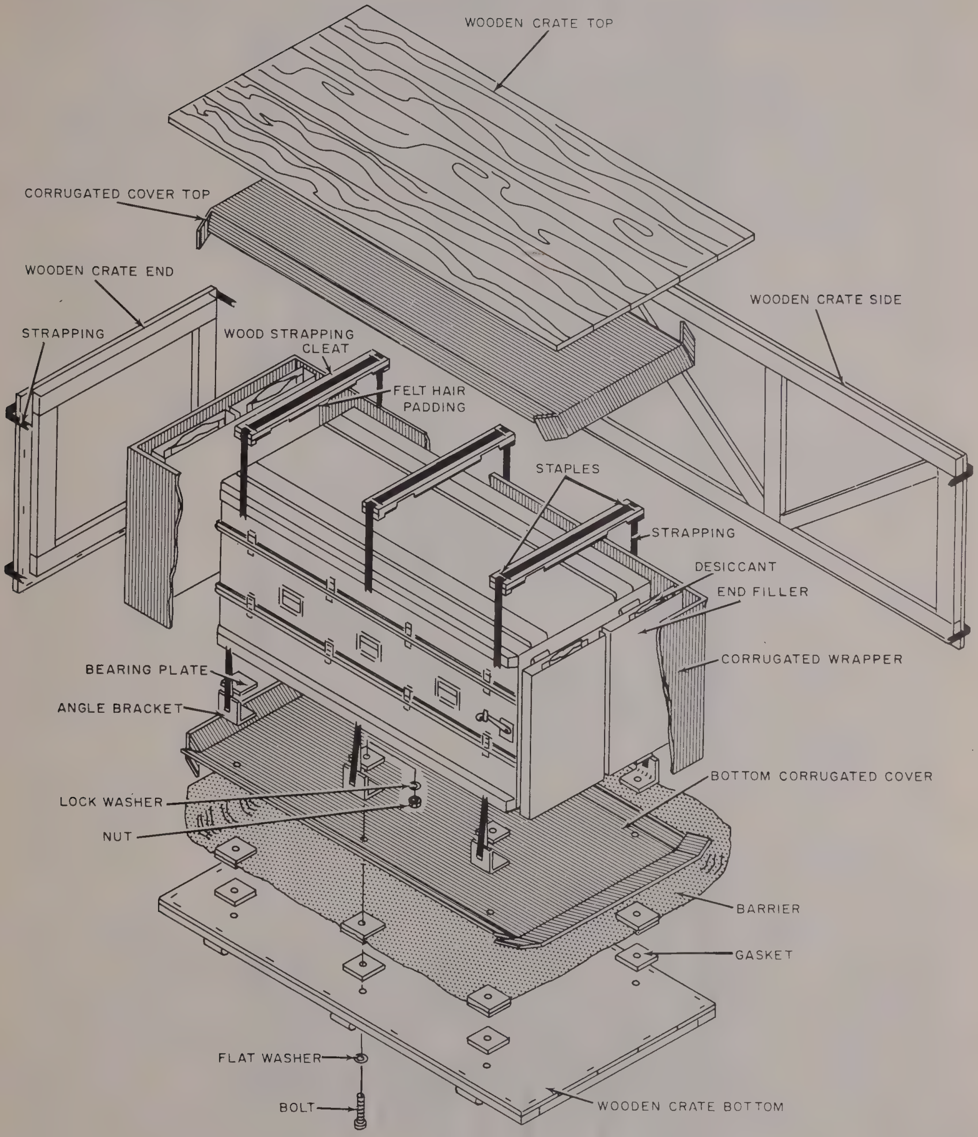

WOODEN CRATE TOP
CORRUGATED COVER TOP
WOODEN CRATE END
WOODEN CRATE SIDE
STRAPPING
WOOD STRAPPING CLEAT
FELT HAIR PADDING
STAPLES
STRAPPING
DESICCANT
END FILLER
CORRUGATED WRAPPER
BEARING PLATE
ANGLE BRACKET
LOCK WASHER
NUT
BOTTOM CORRUGATED COVER
BARRIER
GASKET
FLAT WASHER
BOLT
WOODEN CRATE BOTTOM
TM5091-202

Figure 26. Typical packaging diagram for equipment rack crates.

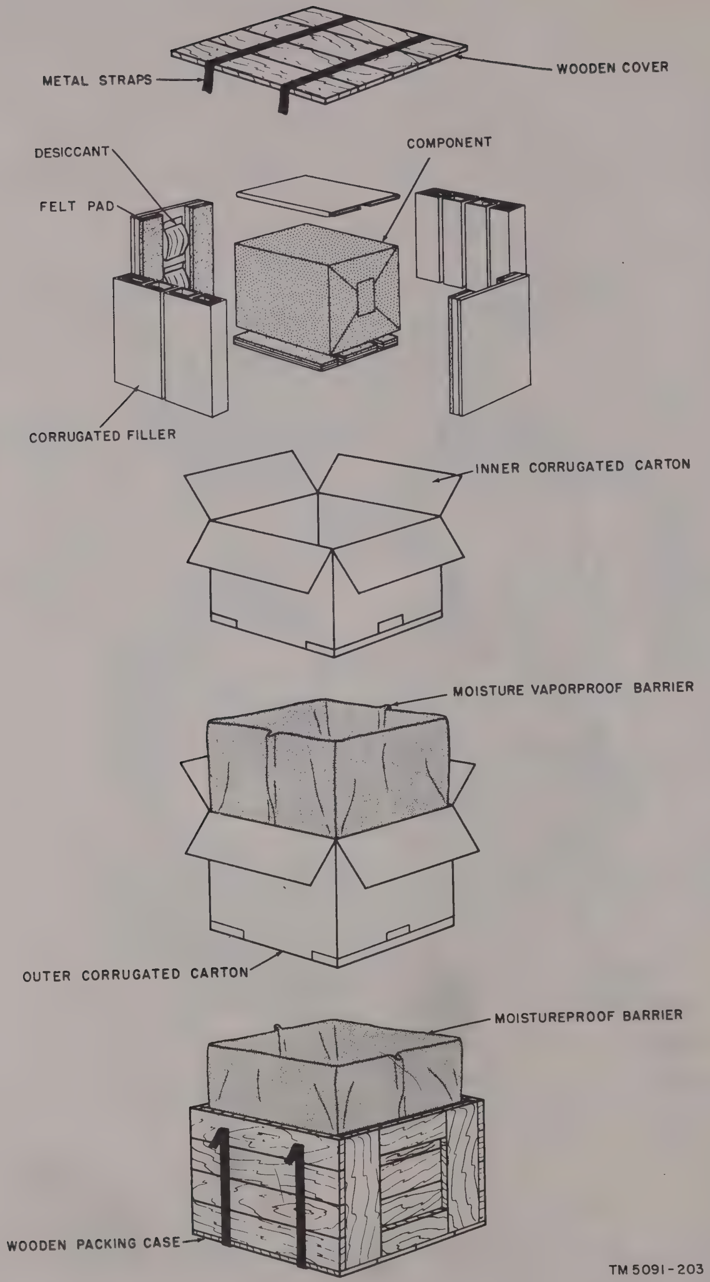

METAL STRAPS
WOODEN COVER
DESICCANT
COMPONENT
FELT PAD
CORRUGATED FILLER
INNER CORRUGATED CARTON
MOISTURE VAPORPROOF BARRIER
OUTER CORRUGATED CARTON
MOISTUREPROOF BARRIER
WOODEN PACKING CASE
TM 5091-203

Figure 27. Typical packaging diagram for small crates.

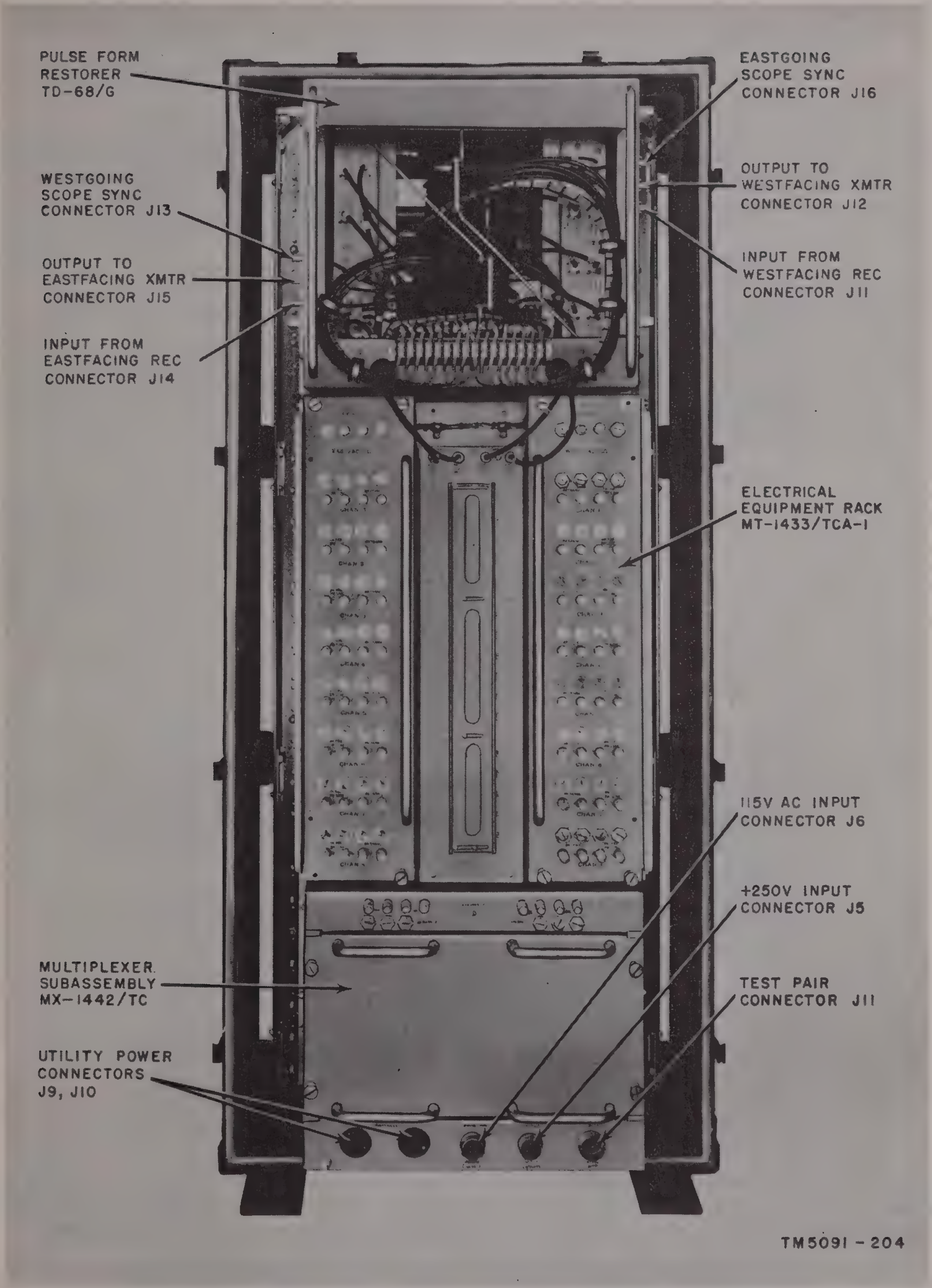

PULSE FORM RESTORER TD-68/G
WESTGOING SCOPE SYNC CONNECTOR J13
OUTPUT TO EASTFACING XMTR CONNECTOR J15
INPUT FROM EASTFACING REC CONNECTOR J14
MULTIPLEXER SUBASSEMBLY MX-1442/TC
UTILITY POWER CONNECTORS J9, J10
EASTGOING SCOPE SYNC CONNECTOR J16
OUTPUT TO WESTFACING XMTR CONNECTOR J12
INPUT FROM WESTFACING REC CONNECTOR J11
ELECTRICAL EQUIPMENT RACK MT-1433/TCA-1
115V AC INPUT CONNECTOR J6
+250V INPUT CONNECTOR J5
TEST PAIR CONNECTOR J11
TM5091 - 204

Figure 28. Multiplexer rack, rear view showing receptacles.

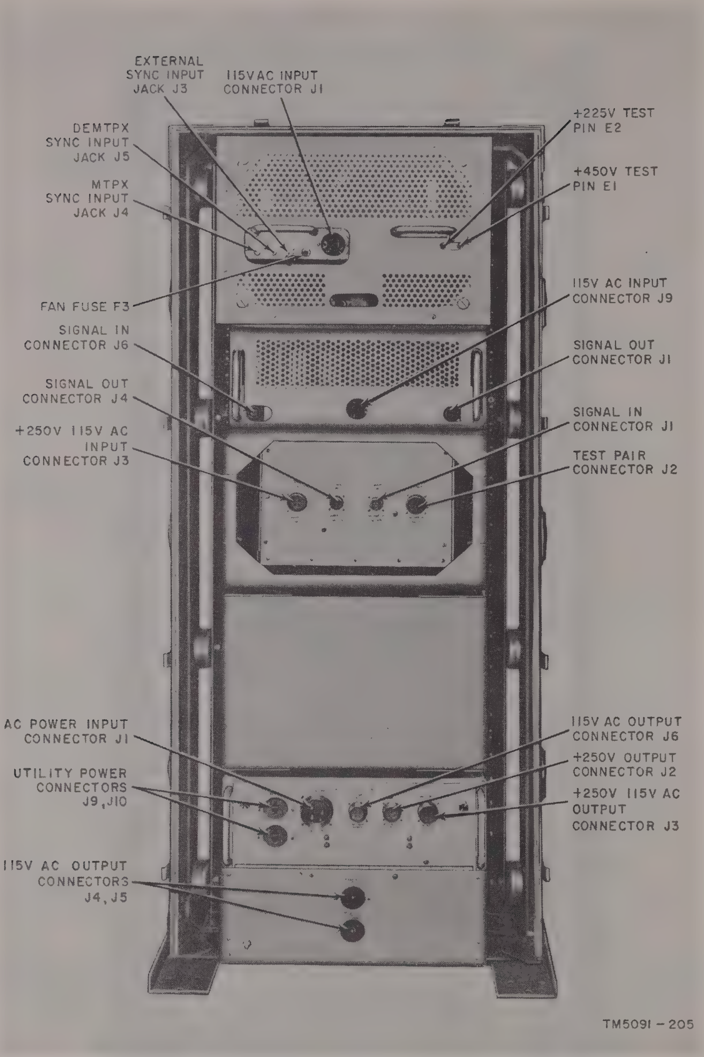

EXTERNAL SYNC INPUT JACK J3
115VAC INPUT CONNECTOR J1
DEMTPX SYNC INPUT JACK J5
MTPX SYNC INPUT JACK J4
FAN FUSE F3
SIGNAL IN CONNECTOR J6
SIGNAL OUT CONNECTOR J4
+250V 115V AC INPUT CONNECTOR J3
+225V TEST PIN E2
+450V TEST PIN E1
115V AC INPUT CONNECTOR J9
SIGNAL OUT CONNECTOR J1
SIGNAL IN CONNECTOR J1
TEST PAIR CONNECTOR J2
AC POWER INPUT CONNECTOR J1
UTILITY POWER CONNECTORS J9, J10
115V AC OUTPUT CONNECTORS J4, J5
115V AC OUTPUT CONNECTOR J6
+250V OUTPUT CONNECTOR J2
+250V 115V AC OUTPUT CONNECTOR J3
TM5091 – 205

Figure 29. Test rack, rear view showing receptacles.

familiar with the installation procedures can assemble the multiplexer group in approximately 15 minutes.

b. The components of the multiplexer group are packed in six crates (par. 6). All the individual subchassis are mounted in the multiplexer and the test racks. Other than connecting the cables and telephone lines, no other assembly is required for this equipment.

c. When the transit cases are opened for the first time, each of the components should be inspected for proper seating of tubes, tightness of front panel controls, and free motion on the runner tracks. Loosen the captive screws of each subchassis with a screw driver, and pull the subchassis forward as far as it will go.

Caution: There is no locking mechanism to hold the individual modems and the audio test set in place; these chassis may be withdrawn completely from the mounting rack. The multiplexer subassembly and power supply do not slide forward.

50. Installation Procedure

a. Unpack the transit cases (par. 48).

b. Check the individual subchassis (par. 49).

c. Connect all cables (par. 51).

d. Refer to figures 28 through 30 for the location of all receptacles, and to figure 31 for the interconnecting diagram.

e. The following table lists the fuses used in the equipment and indicates their functions. Check these fuses to be sure that the proper fuse is installed in the proper clip.

Panel marking	Location		Value in amperes
	Equipment	Figure reference	
EASTGOING +250V fuse	Video restorer	32	6/10
WESTGOING +250V fuse	Video restorer	32	6/10
FAN	Video restorer	32	1/10
FIL LEFT SIDE	Filament supply	34	2
FIL RIGHT SIDE	Filament supply	34	2
B+ GROUP 1	Filament supply	34	3/10
B+ GROUP 2	Filament supply	34	3/10
B+ GROUP 3	Filament supply	34	3/10
B+ GROUP 4	Filament supply	34	3/10
FAN fuse	Filament supply	34	2
BRUSH FUSE	Voltage regulator	37	8
CONTROL FUSE	Voltage regulator	37	3
MOTOR FUSE	Voltage regulator	37	3
UTILITY POWER FUSES	Power supply	38	5
FUSE	Audio test set	40	4
FUSE	Oscilloscope	39	4
FAN	Oscilloscope	96	3/10

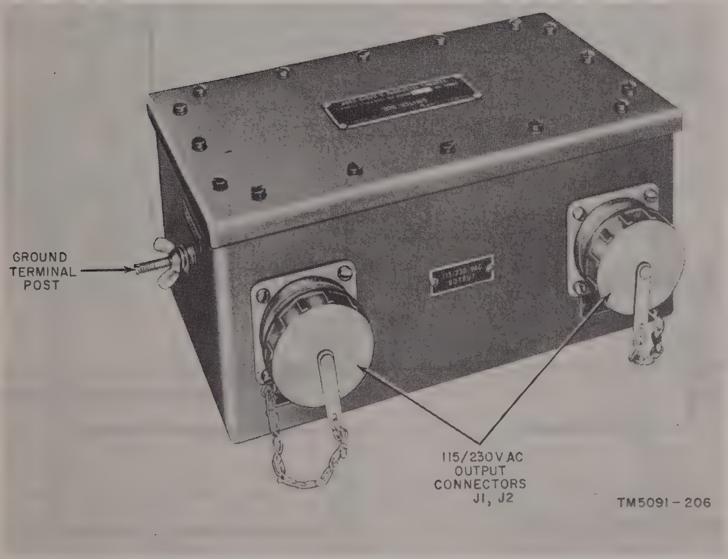


Figure 30. Switch box output receptacles.

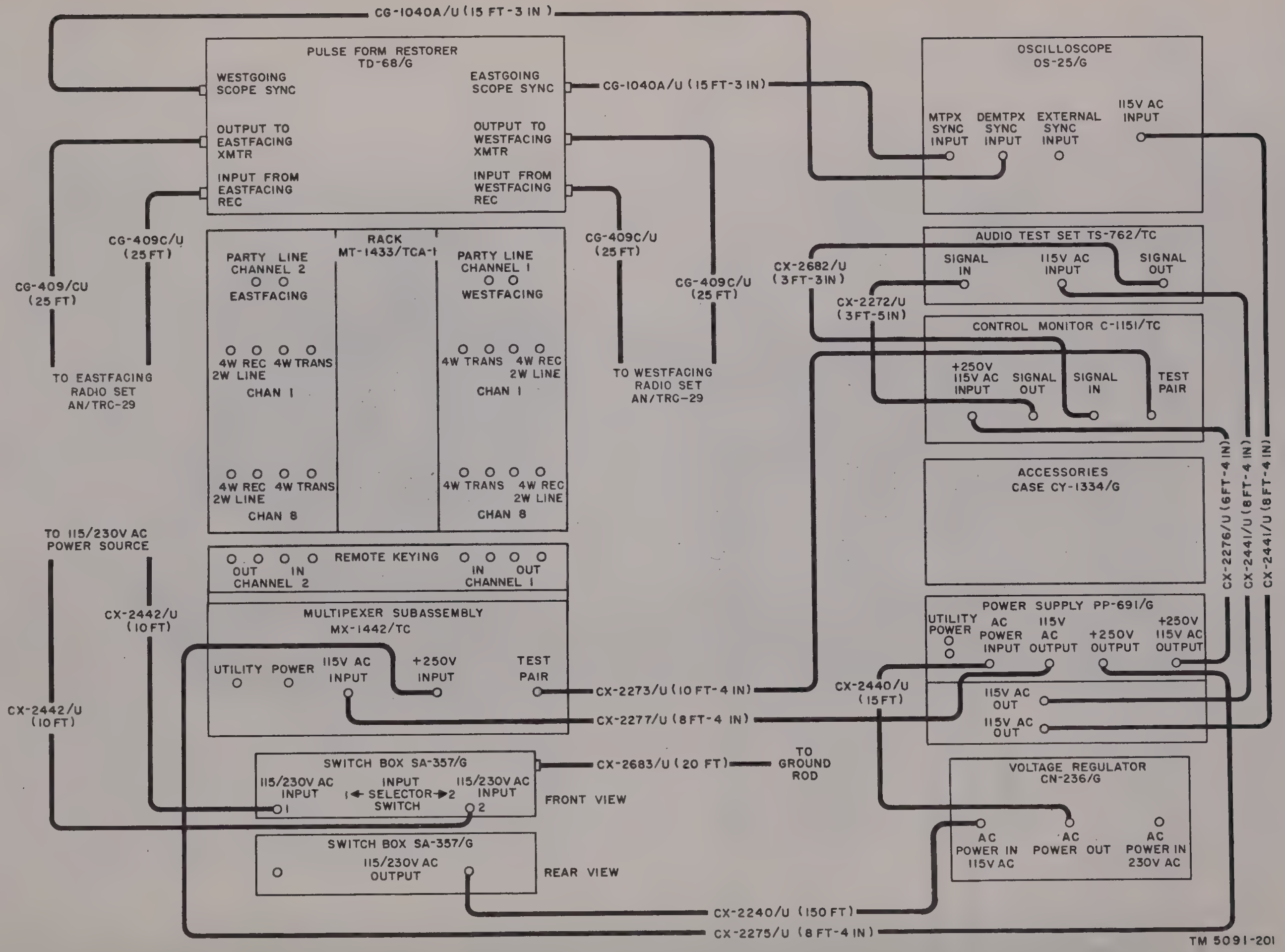

CG-1040A/U (15 FT-3 IN)
PULSE FORM RESTORER TD-68/G
WESTGOING SCOPE SYNC
OUTPUT TO EASTFACING XMTR
INPUT FROM EASTFACING REC
EASTGOING SCOPE SYNC
OUTPUT TO WESTFACING XMTR
INPUT FROM WESTFACING REC
CG-1040A/U (15 FT-3 IN)
OSCILLOSCOPE OS-25/G
MTPX SYNC INPUT
DEMTPX SYNC INPUT
EXTERNAL SYNC INPUT
115V AC INPUT
CG-409/CU (25 FT)
CG-409C/U (25 FT)
TO EASTFACING RADIO SET AN/TRC-29
RACK MT-1433/TCA-1
PARTY LINE CHANNEL 2
EASTFACING
4W REC 2W LINE
4W TRANS
CHAN 1
CHAN 8
PARTY LINE CHANNEL 1
WESTFACING
4W TRANS
4W REC 2W LINE
CHAN 1
CHAN 8
CG-409C/U (25 FT)
CG-409C/U (25 FT)
TO WESTFACING RADIO SET AN/TRC-29
CX-2682/U (3FT-3IN)
CX-2272/U (3FT-5IN)
AUDIO TEST SET TS-762/TC
SIGNAL IN
115V AC INPUT
SIGNAL OUT
CONTROL MONITOR C-1151/TC
+250V 115V AC INPUT
SIGNAL OUT
SIGNAL IN
TEST PAIR
ACCESSORIES CASE CY-1334/G
CX-2276/U (6FT-4 IN)
CX-2441/U (8FT-4 IN)
CX-2441/U (8FT-4 IN)
TO 115/230V AC POWER SOURCE
REMOTE KEYING
OUT
IN
CHANNEL 2
IN
OUT
CHANNEL 1
MULTIPEXER SUBASSEMBLY MX-1442/TC
UTILITY POWER
115V AC INPUT
+250V INPUT
TEST PAIR
CX-2442/U (10 FT)
CX-2442/U (10 FT)
CX-2273/U (10 FT-4 IN)
CX-2277/U (8 FT-4 IN)
POWER SUPPLY PP-691/G
UTILITY POWER
AC POWER INPUT
115V AC OUTPUT
+250V OUTPUT
+250V 115V AC OUTPUT
115V AC OUT
115V AC OUT
CX-2440/U (15 FT)
SWITCH BOX SA-357/G
115/230V AC INPUT
1
INPUT
1 ← SELECTOR → 2
SWITCH
115/230V AC INPUT
2
FRONT VIEW
CX-2683/U (20 FT)
TO GROUND ROD
SWITCH BOX SA-357/G
115/230V AC OUTPUT
REAR VIEW
VOLTAGE REGULATOR CN-236/G
AC POWER IN 115V AC
AC POWER OUT
AC POWER IN 230V AC
CX-2240/U (150 FT)
CX-2275/U (8 FT-4 IN)
TM 5091-201

Figure 31. Interconnection diagram.

51. Cable Connections
(fig. 31)

Make the cable connections outlined below and illustrated in figure 31.

Caution: Do not connect the telephone lines to the binding posts at the rear of the mounting rack until the audio levels are adjusted.

		From			To		
Cable or cord	Length	Cable plug	Component	Connector	Cable plug	Component	Connector
CG–409C/U	25 ft	UG–88/U	Pulse form restorer	INPUT FROM EASTFACING REC	UG–88/U	Eastfacing radio set	VIDEO OUTPUT
CG–409C/U	25 ft	UG–88/U	Pulse form restorer	OUTPUT TO EASTFACING XMTR	UG–88/U	Eastfacing radio set	VIDEO FILTER INPUT
CG–409C/U	25 ft	UG–88/U	Pulse form restorer	INPUT FROM WESTFACING REC	UG–88/U	Westfacing radio set	VIDEO OUTPUT
CG–409C/U	25 ft	UG–88/U	Pulse form restorer	OUTPUT TO WESTFACING XMTR	UG–88/U	Westfacing radio set	VIDEO FILTER INPUT
CG–1040A/U	15 ft, 3 in.	UG–260/U	Pulse form restorer	EASTGOING SCOPE SYCN	UG–260/U	Oscilloscope	MTPX SYNC INPUT
CG–1040A/U	15 ft, 3 in.	UG–260/U	Pulse form restorer	WESTGOING SCOPE SYNC	UG–260/U	Oscilloscope	DEMTPX SYNC INPUT
CX–2277/U	8 ft, 4 in.	AN 3106B–18–10S	Multiplexer subassembly	115V AC INPUT	AN 3106B–18–10P	Power supply	115V AC OUTPUT
CX–2275/U	8 ft, 4 in.	AN 3106B–18–5S	Multiplexer subassembly	+250V INPUT	AN 3106B–18–5P	Power supply	+250V OUTPUT
CX–2273/U	10 ft, 4 in.	AN 3106B–20–7S	Multiplexer subassembly	TEST PAIR	AN 3106B–20–7P	Control monitor	TEST PAIR
CX–2442/U	10 ft, 0 in.	AN 3106A–32–2S	Switch box	115/230 V AC INPUT 1	3 leads	115/230 V AC primary power source	
CX–2442/U	10 ft, 0 in.	AN 3106A–32–2S	Switch box	115/230 V AC INPUT 2	3 leads	115/230 V AC auxiliary power source	
CX–2683/U	20 ft, 0 in.	Eyelet	Switch box	GND CONN	lead	Ground Rod MX–148/G	
CX–2441/U	8 ft, 4 in.	Hubbel No. 7555	Oscilloscope	115V AC INPUT	Hubbel No. 7572	Power supply	115V AC OUT
CX–2272/U	3 ft, 5 in.	AN 3106B–14S–9S	Test set	SIGNAL IN	AN 3106B–14S–9P	Control monitor	SIGNAL OUT
CX–2441/U	8 ft, 4 in.	Hubbel No. 7555	Test set	115V AC INPUT	Hubbel No. 7572	Power supply	115V AC OUT

Cable or cord	Length	From			To		
		Cable plug	Component	Connector	Cable plug	Component	Connector
CX–2682/U	3 ft, 3 in.	AN 3106B–14S–7P	Test set	SIGNAL OUT	AN 3106B–14S–7S	Control monitor	SIGNAL IN
CX–2276/U	6 ft, 4 in.	AN 3106B–20–4S	Control monitor	+250V 115V AC INPUT	AN 3106B–20–4P	Power supply	+250V 115V AC OUTPUT
CX–2440/U	15 ft, 0 in.	AN 3106A–32–2P	Voltage regulator	AC POWER OUTPUT	AN 3106A–32–2S	Power supply	AC POWER INPUT
CX–2440/U	150 ft, 0 in.	AN 3106A–32–2S	Voltage regulator	115V AC POWER INPUT	AN 3106A–32–2P	Switch box	115/230 V AC OUTPUT

52. Service Upon Receipt of Used or Reconditioned Equipment

a. Follow the instructions in paragraphs 48 and 49 for uncrating, unpacking, and checking the equipment.

b. Check the used or reconditioned equipment for tags or other indications of changes in the equipment wiring. If any changes in wiring have been made, note the change on the schematic and wiring diagram in this manual and the book of schematics.

c. Perform all installation and connection procedures given in paragraphs 49 through 51.

Section II. INSTALLATION AND ADJUSTMENT PROCEDURES

Note. Personnel performing the procedures described in this section should be familiar with the use of controls and instruments described in chapter 3.

53. General

a. Multiplexer Group AN/TCA–1 is factory-aligned. Only the oscilloscope, audio test set, initial setting of levels on the modems, and pulse-position alignment require adjustment.

b. This section covers the initial checks and adjustment procedures that must be performed on the multiplexer group after installation and before operation. These procedures are based on interconnection of the multiplexer group into a radio-relay system such as Radio Repeater Set AN/TRC–41. All adjustments are made to insure a zero loss through the repeater.

c. Failure to meet the operation requirements called for in the following paragraphs indicates trouble in the equipment. If this occurs, refer to chapter 4, and perform the complete checks as required.

54. Initial Checks and Adjustments

a. Mechanical Checks.

(1) Check all the cable connections for tightness by turning the cable fasteners by hand.

(2) Check all the power connections at the switch box, the voltage regulator, the rear of the power and filament supplies, the oscilloscope, the test set, and the control monitor.

(3) Be sure that the tubes are tight in their sockets and that the interchassis cables and terminal board connections are tight.

(4) Be sure that the D&I-THRU and PARTY LINE-PRIV switches are properly seated.

(5) Unscrew the four captive screws that hold the video restorer fan (fig. 32), pull the fan assembly out, and turn the blower motor (fig. 33) over by hand to be sure that it is free.

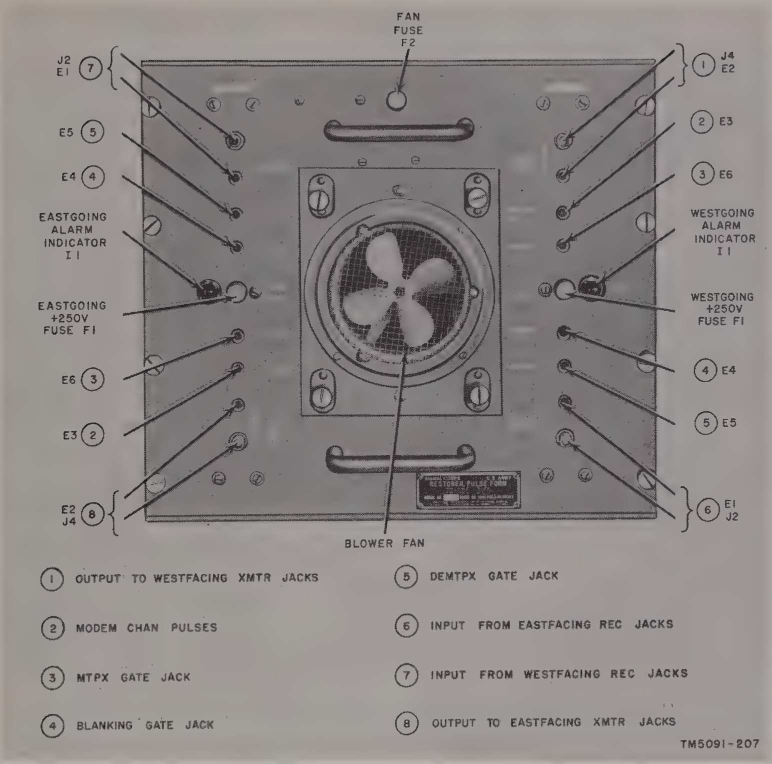

FAN FUSE F2
J2 E1 7
E5 5
E4 4
EASTGOING ALARM INDICATOR I1
EASTGOING +250V FUSE F1
E6 3
E3 2
E2 J4 8
J4 E2 1
2 E3
3 E6
WESTGOING ALARM INDICATOR I1
WESTGOING +250V FUSE F1
4 E4
5 E5
6 E1 J2
BLOWER FAN
1 OUTPUT TO WESTFACING XMTR JACKS
2 MODEM CHAN PULSES
3 MTPX GATE JACK
4 BLANKING GATE JACK
5 DEMTPX GATE JACK
6 INPUT FROM EASTFACING REC JACKS
7 INPUT FROM WESTFACING REC JACKS
8 OUTPUT TO EASTFACING XMTR JACKS
TM5091-207

Figure 32. Video restorer, front view.

(6) Unscrew the four screws that hold the filament supply filter (fig. 34). Remove the filter and turn the blower motor (fig. 35) over by hand to be sure that it is free.

Caution: Be sure that the filter on the filament supply is clean.

(7) Disconnect all auxiliary equipment that may be plugged into the utility power sockets.

b. Electrical Power Connections. Connect the a-c input power to the equipment as follows:

(1) Operate the INPUT SELECTOR SWITCH on the switch box (fig. 36) to either the 115/230 VAC INPUT 1 or 115/230 VAC INPUT 2 position, depending on which connector is connected to the primary power source.

(2) Operate the 230V or 115V INPUT POWER switch on the voltage regulator (fig. 37) to the ON position, depending on the voltage of the input power source. The 115V AC OUTPUT pilot lamp on the voltage regulator should light.

(3) To reset the voltage regulator for operation on a 230-volt power source from operation on a 115-volt power source (or vice versa), proceed as follows:

(*a*) Disconnect the power cord connected to the voltage regulator.

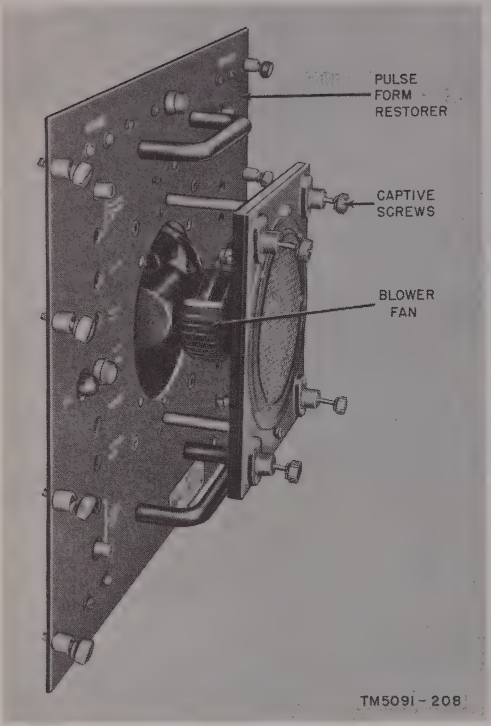


Figure 38. Video restorer blower fan.

(*b*) Loosen the screw that holds the protective bar on the voltage regulator switches.

Note. Both the 230V and 115V AC POWER INPUT switches should be in the OFF position.

(*c*) For 230-volt operation, slide the bar to the extreme left; for 115-volt operation, slide the bar to the extreme right.

(*d*) Tighten the screw that holds the protective bar to lock the bar in place.

(*e*) Connect the power cord to the appropriate receptacle.

(*f*) Place a protective cap on the unused receptacle.

Caution: ALWAYS CAP THE UNUSED RECEPTACLE ON THE VOLTAGE REGULATOR.

(4) Operate the power supply FILAMENT circuit breaker to the ON position. The FILAMENT ON indicator lamp should light, and the LINE VOLTS meter should indicate 115 volts ±1 per cent. If the line voltage is not within these limits, adjust the OUTPUT VOLTAGE potentiometer on the voltage regulator (fig. 37). Throwing the FILAMENT switch to ON applies filament voltage to the entire multiplexer group, except the oscilloscope and test set, which have their own power supply.

Caution: Be sure that all blower fans of the multiplexer group are operating.

(5) Turn the voltage regulator SENSITIVITY control (fig. 37) clockwise until the voltage regulator starts hunting; then turn the control counterclockwise until the hunting just stops. Turn the control counterclockwise another 10° to be sure it has stopped.

(6) Wait 30 seconds and operate the power supply +250V circuit breaker to the ON position. The +250V ON pilot lamp should light. This applies plate voltage to the video restorer and modems. Check for +250 volts between terminal 1 and ground and between terminal 16 and ground on terminal TB1A of the video restorer (fig. 178) with Electronic Multimeter TS–505/U. If this voltage is not read, refer to the trouble-shooting charts in chapter 7.

(7) Operate the oscilloscope ON-OFF switch (fig. 39) and the test set ON-OFF switch (fig. 40) to the ON position. The POWER ON pilot lamps on each unit should light, and the units should be in operation.

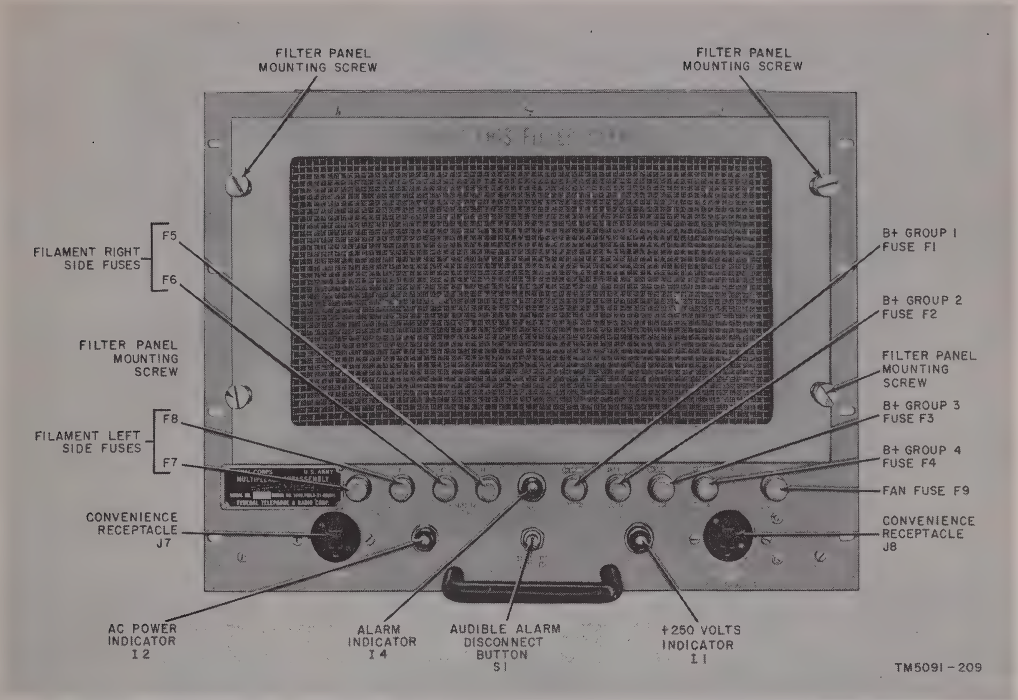

FILTER PANEL MOUNTING SCREW
FILTER PANEL MOUNTING SCREW
FILAMENT RIGHT SIDE FUSES
F5
F6
FILTER PANEL MOUNTING SCREW
FILAMENT LEFT SIDE FUSES
F8
F7
CONVENIENCE RECEPTACLE J7
B+ GROUP 1 FUSE F1
B+ GROUP 2 FUSE F2
FILTER PANEL MOUNTING SCREW
B+ GROUP 3 FUSE F3
B+ GROUP 4 FUSE F4
FAN FUSE F9
CONVENIENCE RECEPTACLE J8
AC POWER INDICATOR I2
ALARM INDICATOR I4
AUDIBLE ALARM DISCONNECT BUTTON S1
+250 VOLTS INDICATOR I1
TM5091-209

Figure 34. Filament supply, front view.

55. Installation Adjustment Procedures

a. Connections. The following switches must be set as indicated before proceeding:

(1) *Modem 2W-4W switch (S1).* Place all modems on a four-wire basis as follows:

(*a*) Unscrew the two front panel captive screws that mount each modem to the mounting rack and pull forward; be careful not to pull the unit out entirely. There is no stop.

(*b*) Pull out the 2W-4W switch (fig. 41) and plug it in with the 4W position pointing toward the arrow on the terminal board.

(2) *Remote keying units* (fig. 9). Unscrew the two captive screws on each remote keying unit, invert and insert so that NORMAL OPERATION is at the top.

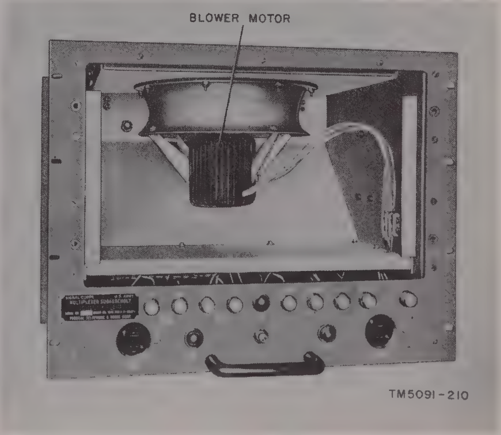

BLOWER MOTOR
TM5091-210

Figure 35. Filament supply blower fan.

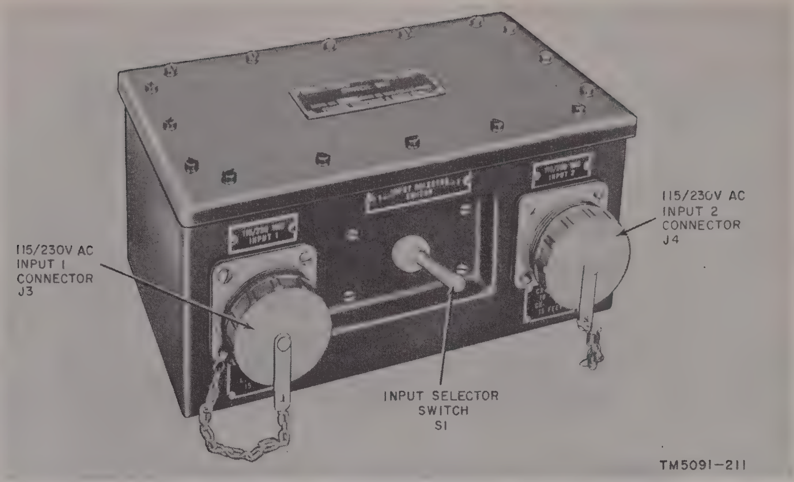

115/230V AC INPUT 2 CONNECTOR J4
115/230V AC INPUT 1 CONNECTOR J3
INPUT SELECTOR SWITCH S1
TM5091-211

Figure 36. Switch box, front view.

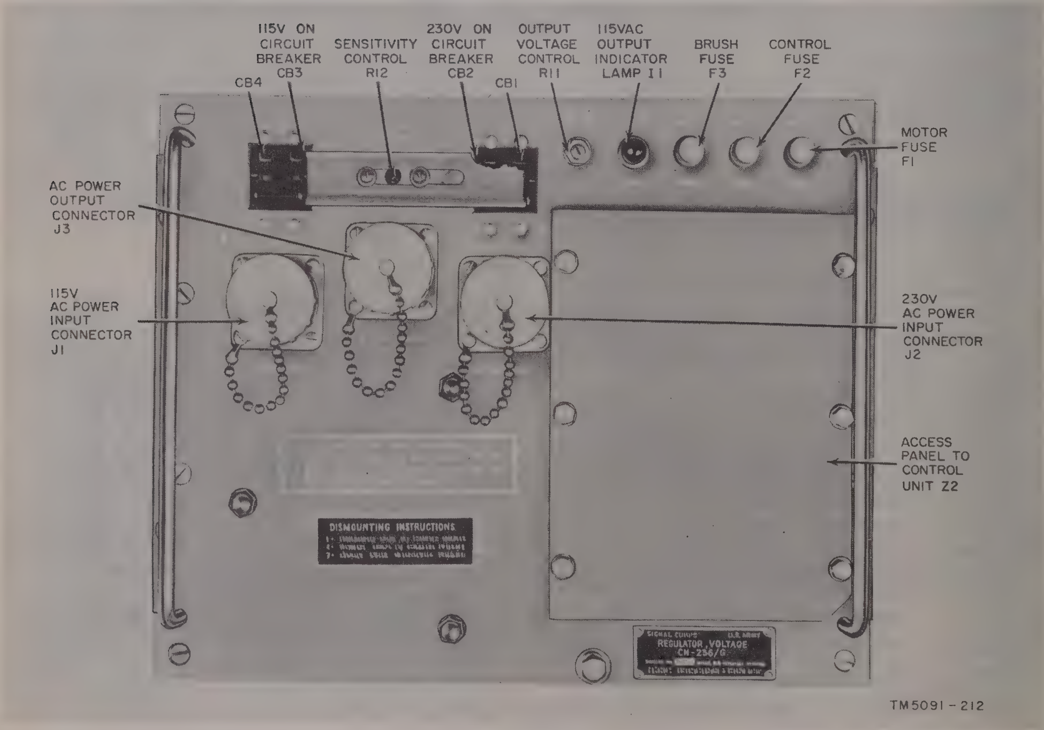

CB4
115V ON CIRCUIT BREAKER CB3
SENSITIVITY CONTROL R12
230V ON CIRCUIT BREAKER CB2
CB1
OUTPUT VOLTAGE CONTROL R11
115VAC OUTPUT INDICATOR LAMP I1
BRUSH FUSE F3
CONTROL FUSE F2
MOTOR FUSE F1
AC POWER OUTPUT CONNECTOR J3
115V AC POWER INPUT CONNECTOR J1
230V AC POWER INPUT CONNECTOR J2
ACCESS PANEL TO CONTROL UNIT Z2
DISMOUNTING INSTRUCTIONS
SIGNAL CORPS U.S. ARMY
REGULATOR, VOLTAGE
CN-256/G
TM5091-212

Figure 37. Voltage regulator, front view.

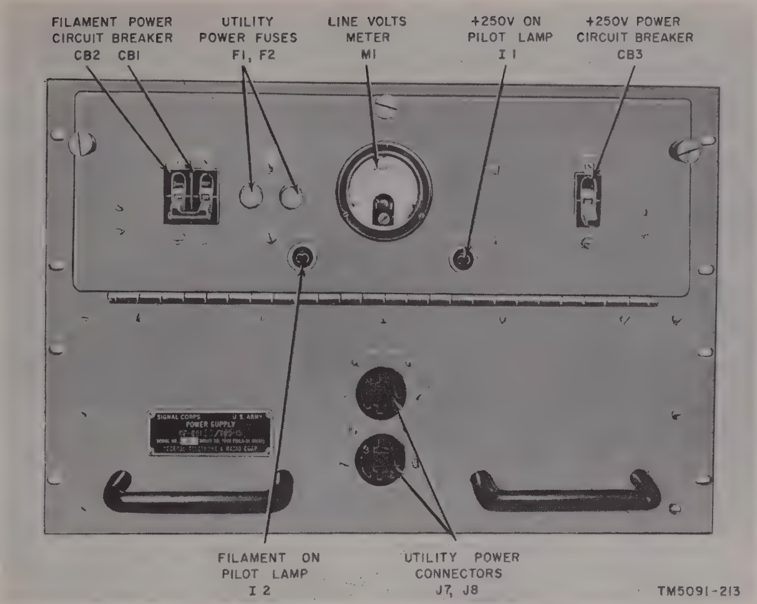

FILAMENT POWER CIRCUIT BREAKER CB2 CB1
UTILITY POWER FUSES F1, F2
LINE VOLTS METER M1
+250V ON PILOT LAMP I 1
+250V POWER CIRCUIT BREAKER CB3
SIGNAL CORPS U. S. ARMY POWER SUPPLY
FILAMENT ON PILOT LAMP I 2
UTILITY POWER CONNECTORS J7, J8
TM5091-213

Figure 38. Power supply, front view.

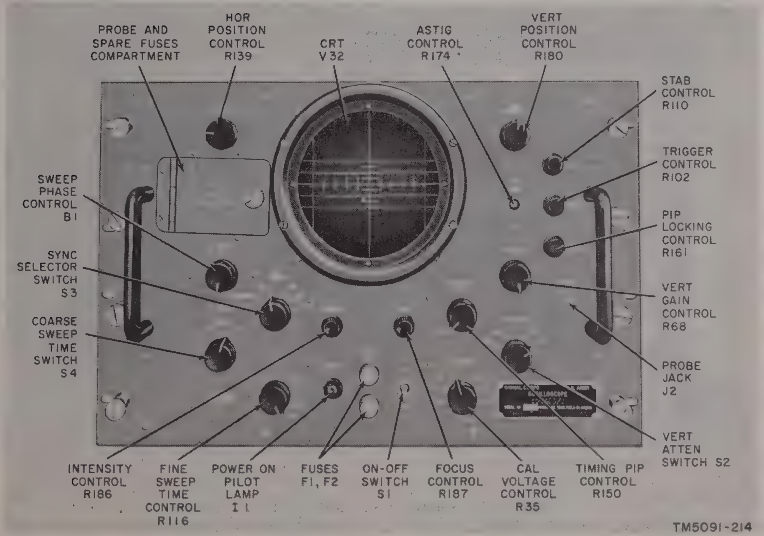

PROBE AND SPARE FUSES COMPARTMENT
HOR POSITION CONTROL R139
CRT V32
ASTIG CONTROL R174
VERT POSITION CONTROL R180
STAB CONTROL R110
TRIGGER CONTROL R102
PIP LOCKING CONTROL R161
VERT GAIN CONTROL R68
PROBE JACK J2
VERT ATTEN SWITCH S2
SWEEP PHASE CONTROL B1
SYNC SELECTOR SWITCH S3
COARSE SWEEP TIME SWITCH S4
INTENSITY CONTROL R186
FINE SWEEP TIME CONTROL R116
POWER ON PILOT LAMP I 1
FUSES F1, F2
ON-OFF SWITCH S1
FOCUS CONTROL R187
CAL VOLTAGE CONTROL R35
TIMING PIP CONTROL R150
TM5091-214

Figure 39. Oscilloscope, front view.

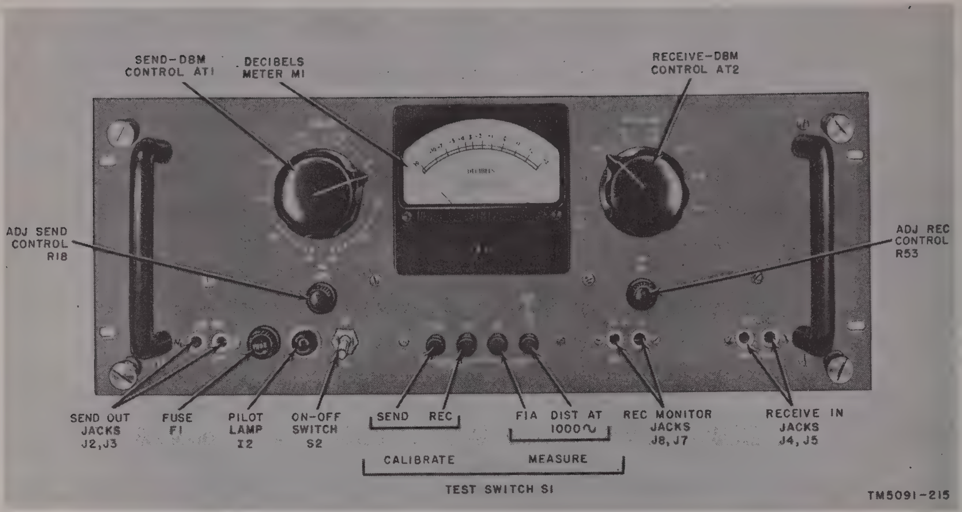

SEND-DBM CONTROL AT1
DECIBELS METER M1
RECEIVE-DBM CONTROL AT2
ADJ SEND CONTROL R18
ADJ REC CONTROL R53
SEND OUT JACKS J2,J3
FUSE F1
PILOT LAMP I2
ON-OFF SWITCH S2
SEND
REC
F1A
DIST AT 1000∿
REC MONITOR JACKS J8, J7
RECEIVE IN JACKS J4, J5
CALIBRATE
MEASURE
TEST SWITCH S1
TM5091-215

Figure 40. Test set, front view.

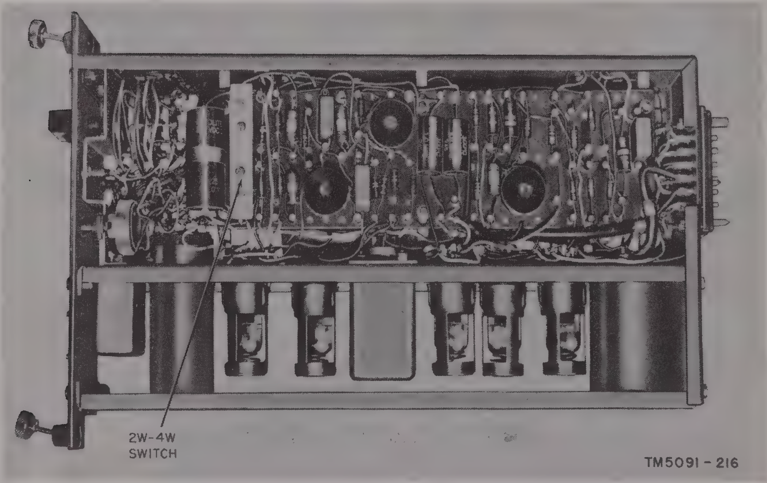

2W-4W SWITCH
TM5091 - 216

Figure 41. Location of modem 2W-4W switch.

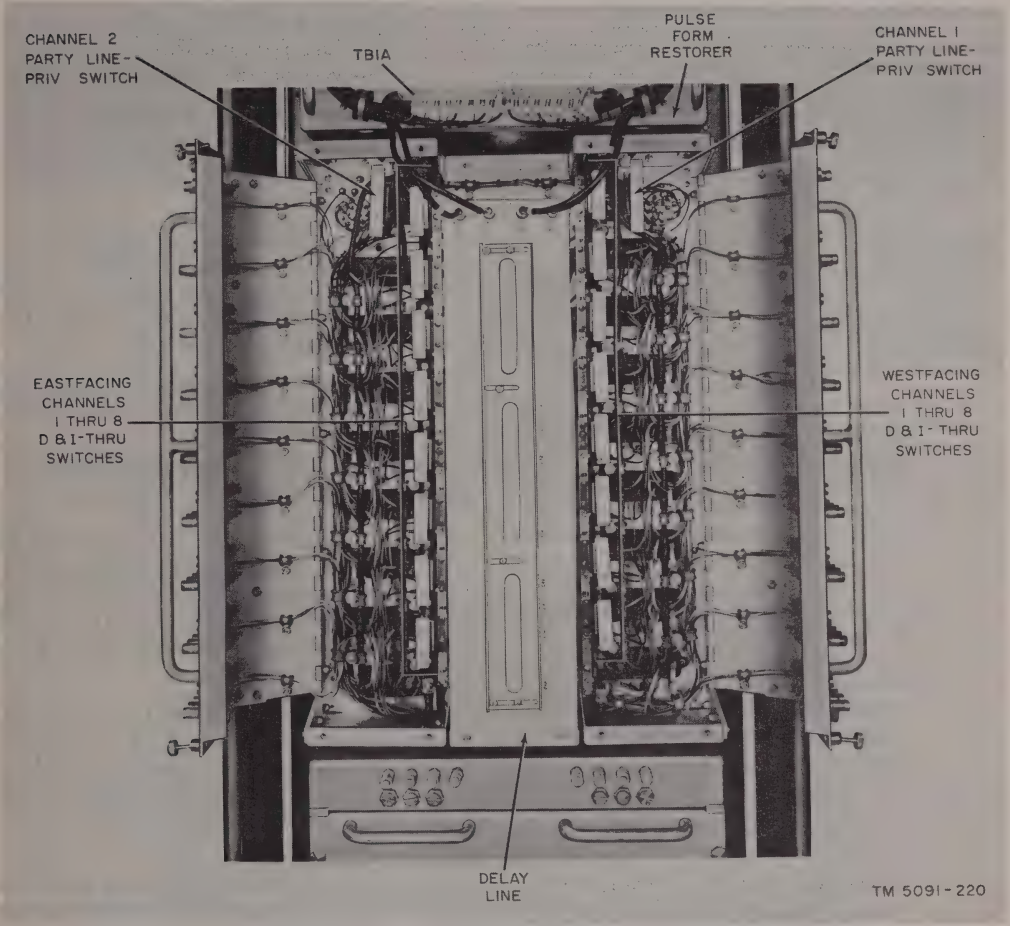

CHANNEL 2 PARTY LINE-PRIV SWITCH
TBIA
PULSE FORM RESTORER
CHANNEL 1 PARTY LINE-PRIV SWITCH
EASTFACING CHANNELS 1 THRU 8 D & I-THRU SWITCHES
WESTFACING CHANNELS 1 THRU 8 D & I-THRU SWITCHES
DELAY LINE
TM 5091-220

Figure 42. Mounting rack, rear view, binding post doors open.

(3) *Party line or private* (fig. 42). Open the four thumb screws on each binding post door alongside the delay line, open the two doors, pull out the two PARTY LINE-PRIV switches (one on each side), invert and insert them so that PARTY LINE is at the top.

(4) *Drop and insert (D&I)-through (THRU)*. Open the doors as described in subparagraph (3) above, pull out the D&I-THRU switches (two on each side), invert and insert them so that D&I is on top.

b. Checking Oscilloscope 60-cycle Voltage Calibrator Wave Form

(1) Set the oscilloscope controls as follows:

Control	Position
SYNC SELECTOR	+INT
COARSE	5000
FINE	10
INTENSITY	Fully counterclockwise
HOR POSITION	Fully clockwise
VERT POSITION	Middle of range
TIMING PIP PHASE	OFF
CAL VOLTAGE	5
VERT ATTEN	CAL
VERT GAIN	Fully clockwise
TRIGGER	Fully counterclockwise
STAB	Fully counterclockwise
ON-OFF SWITCH	ON
PIP LOCKING	Fully counterclockwise

(2) Wait 30 seconds, then advance the INTENSITY control until a vertical line appears on the scope.

(3) Adjust the ASTIG and FOCUS controls until a sharply focused vertical line is seen on the screen.

(4) Rotate the HOR POSITION control to its midposition.

(5) Advance the STAB control until a sweep appears; then turn it in the opposite direction until the sweep just disappears.

(6) Advance the TRIGGER control until a stable image of a clipped sine wave appears (fig. 209). The pattern on the screen is the 60-cycle clipped sine-wave voltage-calibrator wave form that is used for direct-reading voltage calibration of input signals.

(7) The checks in subparagraph *b*(1) through (6) above will give a good indication as to whether the oscilloscope is operating properly.

c. Using Oscilloscope Voltage Calibrator.

(1) Connect the oscilloscope probe to the desired test pin jack.

(2) Adjust the VERT ATTEN and VERT GAIN controls so that the output pulse train is two boxes high. Note the setting of the VERT ATTEN control.

(3) Rotate the VERT ATTEN control to the CAL position. This will supply the 60-cycle voltage calibrator wave form.

(4) Adjust the CAL VOLTAGE control until the voltage calibrator wave form is also two boxes high. Note the control setting.

(5) The amplitude at the pin jack is the product of the VERT ATTEN control setting (subpar. (2) above) and the CAL VOLTAGE control setting (subpar. (4) above), directly in volts.

Note. When using the direct cable probe (not the 10:1 attenuator probe), multiply this value by 10.

d. Calibrating Audio Test Set. Calibrate the audio test set as follows:

(1) Depress the SEND-CALIBRATE switch. The DECIBELS meter pointer should read at the red line. If it does not, slowly rotate the ADJ SEND control until the meter rests on the red line.

(2) Push in the REC-CALIBRATE push switch. The DECIBELS meter should again read at the red line. If it does not, slowly rotate the ADJ REC control until the meter rests on the red line.

Note. Always perform the SEND calibration before the REC calibration, because the REC depends on prior SEND calibration.

e. Checking Wave Forms. With the oscilloscope probe, compare wave forms at the pin jacks of the video restorer and modems against the referenced figures as follows:

(1) *Eastgoing video restorer.*

(*a*) INPUT FROM WESTFACING REC (fig. 59).

(*b*) DEMTPX GATE (fig. 61).

(*c*) BLANKING GATE (fig. 62).

(*d*) MTPX GATE (fig. 63).

(*e*) MODEM CHAN PULSES (fig. 64).

(*f*) OUTPUT TO EASTFACING XMTR (fig. 65).

(2) *Westgoing video restorer.*

(*a*) INPUT FROM EASTFACING REC (fig. 60).

(*b*) DEMTPX GATE (fig. 61).

(*c*) BLANKING GATE (fig. 62).

(*d*) MTPX GATE (fig. 63).

(*e*) MODEM CHAN PULSES (fig. 64).

(*f*) OUTPUT TO WESTFACING XMTR (fig. 60).

(3) *Modems.*

(*a*) PPM (fig. 88).

(*b*) PWM (fig. 92).

f. Checking Alignment of Eastgoing Output Pulse Train.

(1) Push in the NORMAL switch (fig. 43) on the control monitor; turn the power supply FILAMENT power switch to ON (fig. 38).

(2) Turn the power supply (+250V) switch to ON.

(3) Allow the equipment to warm up for stable operation 15 minutes.

(4) While the equipment is warming up, proceed as follows:

(*a*) Check to see that the 2W-4W switch (fig. 41) in each modem is in the 4W position.

(*b*) Check to see that all modem selector switches (fig. 44) are in the OPER position.

(5) After a 15-minute warm up, connect the oscilloscope test probe to the video restorer OUTPUT TO EASTFACING XMTR test point.

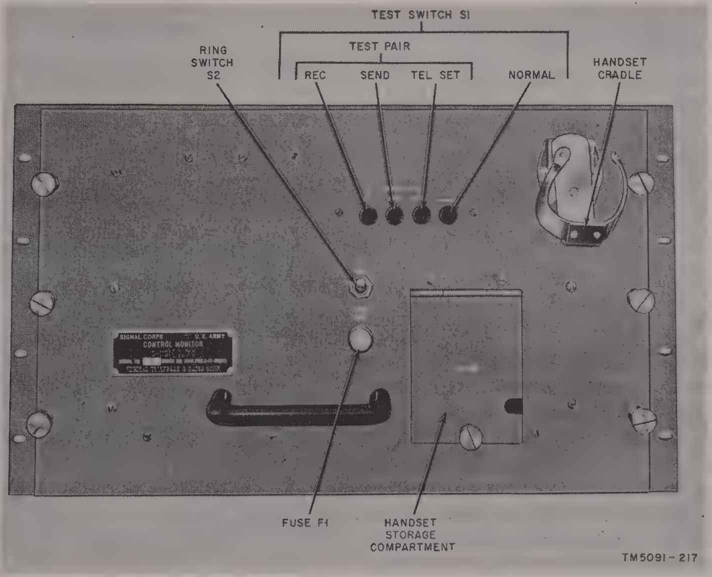

TEST SWITCH S1
TEST PAIR
RING SWITCH S2
REC
SEND
TEL SET
NORMAL
HANDSET CRADLE
SIGNAL CORPS
U.S. ARMY
CONTROL MONITOR
FUSE F1
HANDSET STORAGE COMPARTMENT
TM5091-217

Figure 43. Control monitor, front view.

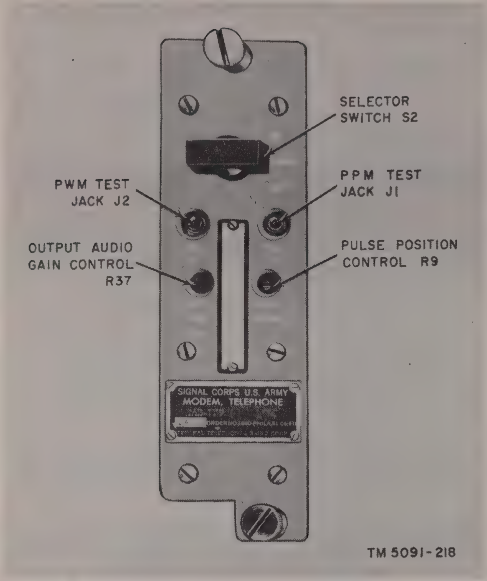


Figure 44. Modem, front view.

(6) Check the output train as follows:

(*a*) Turn the oscilloscope SYNC SELECTOR switch to the MULTIPLEXER position.

(*b*) Turn the COARSE control to the 50 position, and the FINE control to approximately the 5 position.

(*c*) Adjust the VERT ATTEN and VERT GAIN controls to obtain a pattern about 2 centimeters (two lines) high. The pattern now appearing on the scope screen should be similar to that shown in figure 209.

(*d*) Check to see that all the individual channel pulses are in the wave form of the video restorer MOD CHAN PULSES test jack E3. To identify the correct pulse, see that the top right-hand modem unit in the EASTFACING column generates the pulse immediately to the right of the double marker pulse. This pulse is the new inserted channel 1 pulse. The channel 2 pulse is generated by the second modem down from the top. It is the second pulse to the right of the double marker pulse. The remainder of the modems on the right side generate pulses 3 through 8.

(7) Align the pulse train as follows:

(*a*) Adjust the oscilloscope COARSE and FINE controls so that two successive markers (double pulse) occupy approximately 9 centimeters (cm) (nine lines) across the oscilloscope screen.

(*b*) Turn on the oscilloscope timing pips. If the timing pips are not locked, set the TIMING PIP PHASE control to the center of its range and adjust the PIP LOCKING control until the pips are locked. Adjust the phase of the pips with the TIMING PIP PHASE control so that a timing pip begins to ride into the leading edge of the second marker pulse. This will show a slight amplitude increase of the second marker pulse.

(*c*) Vary the PULSE POSITION control (fig. 44) of the channel 1 eastfacing modem until the leading edge of the channel 1 eastfacing pulse rides into the timing pip immedi-

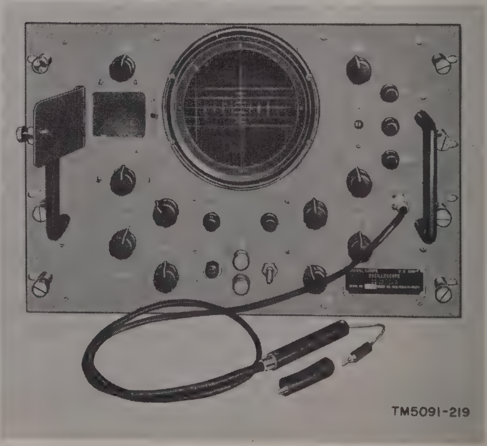


Figure 45. Oscilloscope with probe connected.

ately to the right of the second marker pulse. Adjust the PULSE POSITION control so that the channel 1 pulse approaches the timing pip from the right.

(*d*) Channel 1 is aligned when its amplitude just begins to increase as the second marker pulse did under its alignment (subpar. (*b*) above).

(*e*) Repeat the steps in subparagraphs (*c*) and (*d*) above for channels 2 through 8.

(*f*) Check the complete pulse train alignment as follows:

1. Change the TIMING PIP PHASE control very slightly.

2. All pulses (including the second marker pulse) should increase and decrease in amplitude simultaneously. If any channel pulse for channels 1 through 8 does not act simultaneously, repeat the alignment procedure for this channel, and then check the alignment of the entire train again.

g. Checking Alignment of Westgoing Output Pulse Train. To check the alignment of the westgoing output pulse train, repeat the procedures described in subparagraph *f* above, with the following exceptions:

(1) Connect the oscilloscope to the OUTPUT TO WESTFACING XMTR, with the oscilloscope SYNC SELECTOR switch in the DEMULTIPLEXER position.

(2) The top left-hand modem unit in the westfacing column generates the pulse immediately to the right of the double marker (channel 1).

h. Checking Amplitude of Eastgoing Output Pulse Train. Check the amplitude of the eastgoing pulse train as follows:

(1) Perform all the procedures described in subparagraphs *b* through *g* above.

(2) Connect the oscilloscope probe to the OUTPUT TO EASTFACING XMTR test jack on the video restorer.

(3) Adjust the VERT ATTEN and VERT GAIN controls so that the output pulse train is two boxes high. Note the setting of the VERT ATTEN control.

(4) Rotate the VERT ATTEN control to the CAL position. This will supply the 60-cycle voltage calibrator wave form.

(5) Adjust the CAL VOLTAGE control until the voltage calibrator wave form also is two boxes high. Note the control setting.

(6) The amplitude of the output pulse train is the product of the VERT ATTEN control setting (subpar. (3) above) and the CAL VOLTAGE control setting (subpar. (5) above), directly in volts.

(7) With a 23-channel input, and the video restorer P.T. OUT AMPL switch in LOW, the pulse train level on the oscilloscope should be .25 volt from base level to peak. If this value is not obtained, adjust the video restorer slotted screw driver SYM ADJ control until the .25-volt level is obtained. If an output greater than .25 volt is required from the video restorer, throw the P.T. OUT AMPL switch to HIGH. An increase of 6 db (.5 volt) can be obtained.

(8) With a 45-channel input, the output to the eastfacing transmitter should be adjusted with the SYM ADJ control so that the positive and negative pulse train amplitudes are of equal magnitudes. With the P.T OUT AMPL switch in the LOW position, the level should be greater than .4 volt peak to peak. With the P.T. OUT AMPL switch in the HIGH position, the level should be greater than .8 volt.

i. Checking Amplitude of Westgoing Output Pulse Train. Check the amplitude of the westgoing output pulse train exactly as described in subparagraph *h* above, except that the direct cable probe of the oscilloscope is connected to the video restorer OUTPUT TO WESTFACING XMTR test jack.

j. Alignment of Video Levels.

(1) *General.* When Radio Set AN/TRC–29 and Multiplexer Group AN/TCA–1 are set up as part of a multihop radio-relay link, the following video level requirements will result in optimum operation of the system.

(*a*) All transmitters modulating 100 per cent.

(*b*) The output video level of each multiplexer group to be one-half of its input video level.

Note. Only under conditions of exceedingly long lengths of cable between equipments and under certain conditions of 45-channel operation will it be difficult to maintain the above requirements (par. 108).

(2) *23-channel operation.*

(*a*) *Normal operating conditions.* Set the video levels as follows:

1. At the repeater station, observe the wave form at the AN/TCA–1 INPUT FROM EASTFACING REC test jack and adjust the video output level control on the eastfacing AN/TRC–29 receiver for a base line to peak pulse amplitude of .5 volt.

2. At the repeater station AN/TCA–1 westgoing side, set P.T. OUT AMPL switch S2 in the LOW position, and adjust SYM ADJ control for a base line to peak pulse train amplitude of .25 volt at the front panel OUTPUT TO WESTFACING XMTR test jack.

3. At the repeater station Radio Set AN/TRC–29, adjust the video input level on the westfacing transmitter for 100 per cent modulation.

4. Repeat procedures given in subparagraph *j*(2)(*a*)*1* through *3* above for the other direction of transmission.

(*b*) *Nonoptimum operating conditions.* The nonoptimum operating conditions of the multiplexer group are those that cause a lower than .5-volt pulse amplitude input to the multiplexer group. This may be caused by exceedingly long cable lengths between the AN/TCA–1 and the AN/TRC–29 or insufficient output of the AN/TRC–29 receiver. Under this condition, set the video level of the AN/TCA–1 as follows:

1. At the repeater, observe the wave form at the AN/TCA–1 front panel INPUT FROM EASTFACING REC test jack and adjust the video output level control on the eastfacing AN/TRC–29 receiver for a maximum input level.

2. At the repeater station AN/TCA–1, set the westgoing P.T. OUT AMPL switch S2 in the HIGH position.

3. With a field telephone, contact personnel at the westfacing transmitter and adjust the AN/TCA–1 westgoing SYM ADJ control for as low a level as possible to modulate the transmitter 100 per cent.

4. Repeat the instructions in subparagraph *j*(2)(*b*)*1* through *3* above for the other direction of transmission.

(3) *45-channel operation.*

(*a*) *Normal operating conditions.* Set the video levels as follows:

1. At the repeater station, observe the wave form at the AN/TCA–1 front panel INPUT FROM EASTFACING REC test jack and adjust the video output level control on the eastfacing AN/TRC–29 receiver for a peak-to-peak pulse train amplitude of 1 volt.

2. At the repeater station AN/TCA–1 westgoing side, place the 23 CHAN-45 CHAN switch in the 45 CHAN position, set P.T. OUT AMPL switch S2 in the LOW position, and adjust the SYM ADJ control for a symmetrical pulse train (positive and negative pulse train of equal amplitude) at the OUTPUT TO WESTFACING XMTR test jack.

3. At the repeater station Radio Set AN/TRC–29, adjust the video input level control on the westfacing transmitter for 100 per cent modulation.

4. Repeat the procedures given in subparagraph *j*(3) (*a*)*1* through *3* above for the other direction of transmission.

(*b*) *Nonoptimum conditions.* The nonoptimum operating conditions of the AN/TCA–1 are those that cause a lower than 1-volt peak-to-peak pulse amplitude input to the AN/TCA–1. This may be caused by exceedingly long cable lengths between the AN/TCA–1 and the AN/TRC–29 or insufficient output of the AN/TRC–29 receiver. Under this condition, set the video level of the AN/TCA–1 as follows:

1. At the repeater station, observe the wave form at the AN/TCA–1 front panel INPUT FROM EASTFACING REC test jack and adjust the video output level control on the eastfacing AN/TRC–29 receiver for a maximum input peak-to-peak level.

2. At the repeater station westgoing side AN/TCA–1, place 23 CHAN-45 CHAN switch in the 45 CHAN position, the P.T. OUT AMPL switch in the HIGH position, and adjust the SYM ADJ control for a symmetrical pulse train at the front panel OUTPUT TO WESTFACING XMTR test jack.

3. At the repeater station Radio Set AN/TRC–29, adjust the video input level control on the westfacing transmitter for 100 per cent modulation.

4. Repeat the procedures given in subparagraph *j*(3) (*b*)*1* through *3* above for the other direction of transmission.

k. *Alignment of Audio Levels.*

(1) *General.* This system alignment procedure precludes a talking circuit in operation independent of the equipment until the channel 1 order-wire circuit is aligned. After the orderwire channel is available, connect a field Telephone EE–8-B to the PARTY LINE CHANNEL 1 binding posts at all repeaters and use the orderwire circuit as directed in paragraph 72.

(2) *Alignment of channels 1 and 2 at a terminal and repeater.* Channels 1 and 2 of both Pulse Form Restorer Group AN/TRA–10 and Multiplexer Group AN/TCA–1 are aligned identically in the following manner:

(*a*) *At east terminal AN/TCC–13.*

1. Set control monitor test switch S1 in the SEND position.

2. Turn modem channel 1 selector switch S2 to the SR position.

3. Place the remote keying unit in the NORMAL OPERATION position.

(*b*) *At repeater AN/TRA–10 or AN/TCA–1.*

1. Set the modem channel 1 eastfacing and westfacing 2W-4W switch S1 in the 4W position.

2. Place the remote keying unit in the NORMAL OPERATION position.

3. Place the channel 1 PARTY LINE-PRIV switch in the PARTY LINE position.

4. Place the channel 1 D&I-THRU switch in the D&I position.

5. At the AN/TCA–1 only, set control monitor test switch S1 in the NORMAL position.

(*c*) *At east terminal AN/TCC–13.* At the east terminal AN/TCC–13, modulate channel 1 with full modulation (–4 dbm for four-wire and 0 dbm (decibels referred to 1 milliwatt in 600 ohms) for two-wire).

(*d*) *At repeater AN/TRA–10 or AN/TCA–1.*

1. Connect the oscilloscope and direct probe to the front panel OUTPUT TO WESTFACING XMTR test jack.

2. Adjust channel 1 modem OUTPUT AUDIO GAIN control until a deviation of ±.5 microsecond (usec) is obtained on the oscilloscope.

(*e*) *At west terminal AN/TCC–13.*

1. Place the remote keying unit in the NORMAL OPERATION position.

2. Set the control monitor test switch S1 in the REC position.

3. Turn the channel 1 modem selector switch S2 to the RR position.

(*f*) *At west terminal AN/TCC–13.* At the west terminal AN/TCC–13, adjust the channel 1 modem OUTPUT AUDIO GAIN control until a reading of 0 dbm for four-wire or a reading of –3 dbm for two-wire is obtained on the audio test set.

(*g*) *Channel 2 eastfacing.* Repeat the procedures given in subparagraph *k*(2) (*a*) through (*f*) above for channel 2.

(*h*) *Westfacing alignment.* Repeat the procedures given in subparagraph *k*(2)(*a*) through (*g*) above for the other direction of transmission.

Note. The above procedures insure zero through loss to prevent cumulative gain or loss through a number of repeaters. Local sending and receiving levels are fixed and will be correct when the through loss adjustment has been made correctly.

(3) *Alignment of channels 3 through 8 from terminal to repeater AN/TCA–1.*

(*a*) *At east terminal AN/TCC–13.*

1. Set the control monitor test switch to the SEND position.

2. Turn the channel 3 modem selector switch S2 to the SR position.

(*b*) *At repeater AN/TCA–1.*

1. Set the control monitor test switch S1 in the REC position.

2. Turn the eastfacing channel 3 modem selector switch S2 to the RR position.

3. Place the eastfacing channel 3 D&I-THRU switch in the D&I position.

(*c*) *At east terminal AN/TCC–13.* At east terminal AN/TCC–13, modulate channel 3 with full modulation (–4 dbm for four-wire or 0 dbm for two-wire).

(*d*) *At repeater AN/TCA–1.* At repeater AN/TCA–1, adjust the eastfacing channel 3 modem OUTPUT AUDIO GAIN control until a read-

THIS ADDENDA WILL REMAIN IN EFFECT ONLY UNTIL THE INFORMATION IS PUBLISHED IN AN OFFICIAL DEPARTMENT OF THE ARMY PUBLICATION

ADDENDA NO. 1
NOVEMBER 15, 1955

ADDENDA NO. 1
TO
INSTRUCTION BOOK
FOR
MULTIPLEXER GROUP AN/TCA-1

The following information modifies the instruction book for Multiplexer Set AN/TCA-1, published on Order No. 4663-Phila-52. The equipment specifically covered in this addenda is:

Name	Order No.	Serial No.
Pulse Form Restorer TD-68/G	4663-Phila-52	1 through

Personnel using this equipment and having custody of this instruction book will enter notations beside each affected paragraph and figure to indicate the presence of this supplementary information.

Page 122. Figure 115. Add the following "Note" to figure 115.

Note. For Pulse Form Restorer TD-68/G in all units bearing Order No. 4663-Phila-52 the value of resistor R114 has been changed from 390 ohms to 470 ohms. Coupling diode CR8, type IN38A, has been added to the plate circuit of V21. This diode is connected between the junction of C58 and C59 and the junction of R86 (value changed) and R87 (value changed) in the plate circuit of V14.

Page 122. Figure 115.1. After figure 115 add figure 115.1, Ringing circuit simplified schematic, supplied with this addenda.

Page 123. Paragraph 122 e. For Pulse Form Restorer TD-68/G for all units bearing Order No. 4663-Phila-52 add subparagraph e to paragraph 122.

e. Coupling Diode CR8 (figure 115.1) Coupling diode CR8 regulates the voltage at the plate of V21. In the absence of a pulse (ringing) the voltage at the plate of V21 increases. Under this condition CR8, which is biased to cut-off by its connection to the plate circuit of V14, draws current and returns the plate voltage of V21 to the proper potential. The regulation of the plate potential of V21 is necessary since a very high voltage at this point will prevent ringing. This is liable to occur when a number of channels ring simultaneously.

Page 130. Paragraph 128 b (4). Add the following "Note" to subparagraph b (4).

Note. For Pulse Form Restorer TD-68/G, in all units bearing Order No. 4663-Phila-52, the fixed cathode voltage of +12 volts is increased to approximately +14 volts. This increase in voltage is due to the increase in value of R68 from 1500 ohms to 2700 ohms.

Page 131. Figure 125. Add the following "Note" to figure 125.

Note. For Pulse Form Restorer TD-68/G, in all units bearing Order No. 4663-Phila-52 the value of R68 has been changed from 1500 ohms to 2700 ohms.

Page 137. Paragraph 130 b. For Pulse Form Restorer TD-68/G, in all units bearing Order No. 4663-Phila-52 substitute the following for subparagraph b.

b. Amplifier V13B and Cathode Follower V13A (figure 132.1). The blanking gate is applied to the grid of V13B through coupling capacitor C44 and INPUT BLANKING GATES J6. The blanking gate is developed across grid leak resistor R151 and the grid of V13B. Tube V13B is biased to operate as a limiter. The blanking gate is amplified by V13B, developed across cathode load resistor R84 of cathode follower V13A and coupled through capacitor C37 to the cathode of blanker tube V11B. The output of V13A is also coupled to BLANKING GATE test point E4 through capacitor C43. For V13B, resistor R85 is the grid return to B+ and resistor R151 is the grid leak resistor. Resistor R81 is used to prevent parasitic oscillations. Resistor R82 is the plate load resistor for V13B and capacitor C42 is the output coupling capacitor. Resistor R152 is the common cathode resistor for V13A and V13B. Capacitor C75 is the cathode bypass capacitor for both V13A and V13B. For tube V13A resistor R83 is the grid return resistor R84 is the cathode load resistor and capacitor C37 is output coupling capacitor. Capacitor C43 couples the blanking gate to test point E4.

Page 138. Figure 132. Delete figure 132 and replace with figure 132.1 supplied with this addenda.

Figure 179. Pullout illustration. Add the following "Note" to figure 179.

Note. For Pulse Form Restorer TD-68/G, in all units bearing Order No. 4663-Phila-52 the following voltages and resistances have been changed. The new voltage and resistance readings are approximate.

Resistances	
Original	New
Tube V11	Tube V11
Pin 8 9300 ohms	Pin 8 10,900 ohms
Tube V13	Tube V13
Pin 2 475K	Pin 2 476K
Pin 3 4700 ohms	Pin 3 6600
Pin 6 16K	Pin 6 25K

Voltages	
Original	New
Tube V11	Tube V11
Pin 8 12.1V	Pin 8 14V
Tube V13	Tube V13
Pin 2 -48V	Pin 2 -46V
Pin 3 13.3V	Pin 3 15V
Pin 6 124V	Pin 6 105V

Resistances		Voltages	
Original	New	Original	New
Pin 7 1 meg	Pin 7 200K	Pin 7 0V	Pin 7 1V
Pin 8 0	Pin 8 1K	Pin 8 0V	Pin 8 2V
Tube V14	Tube V14	Tube V14	Tube V14
Pin 3 27K	Pin 3 8200 ohms	Pin 3 75V	Pin 3 75V
Pin 5 27K	Pin 5 8200 ohms	Pin 5 75V	Pin 5 75V
Pin 7 27K	Pin 7 8200 ohms	Pin 7 75V	Pin 7 75V
Tube V21	Tube V21	Tube V21	Tube V21
Pin 8 5100 ohms	Pin 8 5300 ohms	Pin 8 243V	Pin 8 240V

Page 201. Paragraph 179 c. In the first sentence of subparagraph c change phrase (across 3,000-ohm terminating resistor R3, R5, R9, or R11) to (across 3,000-ohm terminating resistor R9, R18, R27, or R35).

Figure 260. Pullout illustrations. Add the following "Note" to figure 260.

Note. The portions of the schematic affected by the changes described in Addenda No. 1 are as shown in figure 260.1 supplied with the Addenda.

Figure 260. Pullout illustration. Add figure 260.1 after figure 260.

Figure 260.1. Video Restorer, schematic of (changed) blanker and cathode follower V11, cathode follower and amplifier V13, power amplifier V21, 75V supply V14, and 105V supply V28.

Figure 274. Pullout illustration. Add the following "Note" to figure 274.

Note. The portions of the wiring diagram affected by the changed described in Addenda No. 1 are as shown in figure 260.1 supplied with the Addenda.

Figure 274. Pullout illustration. Add figure 274.1 after figure 274.

Figure 274.1. Video Restorer wiring diagram of (changed) blanker and cathode follower V11, cathode follower and amplifier V13, power amplifier V21, 75V supply V14, and 105V supply V28.

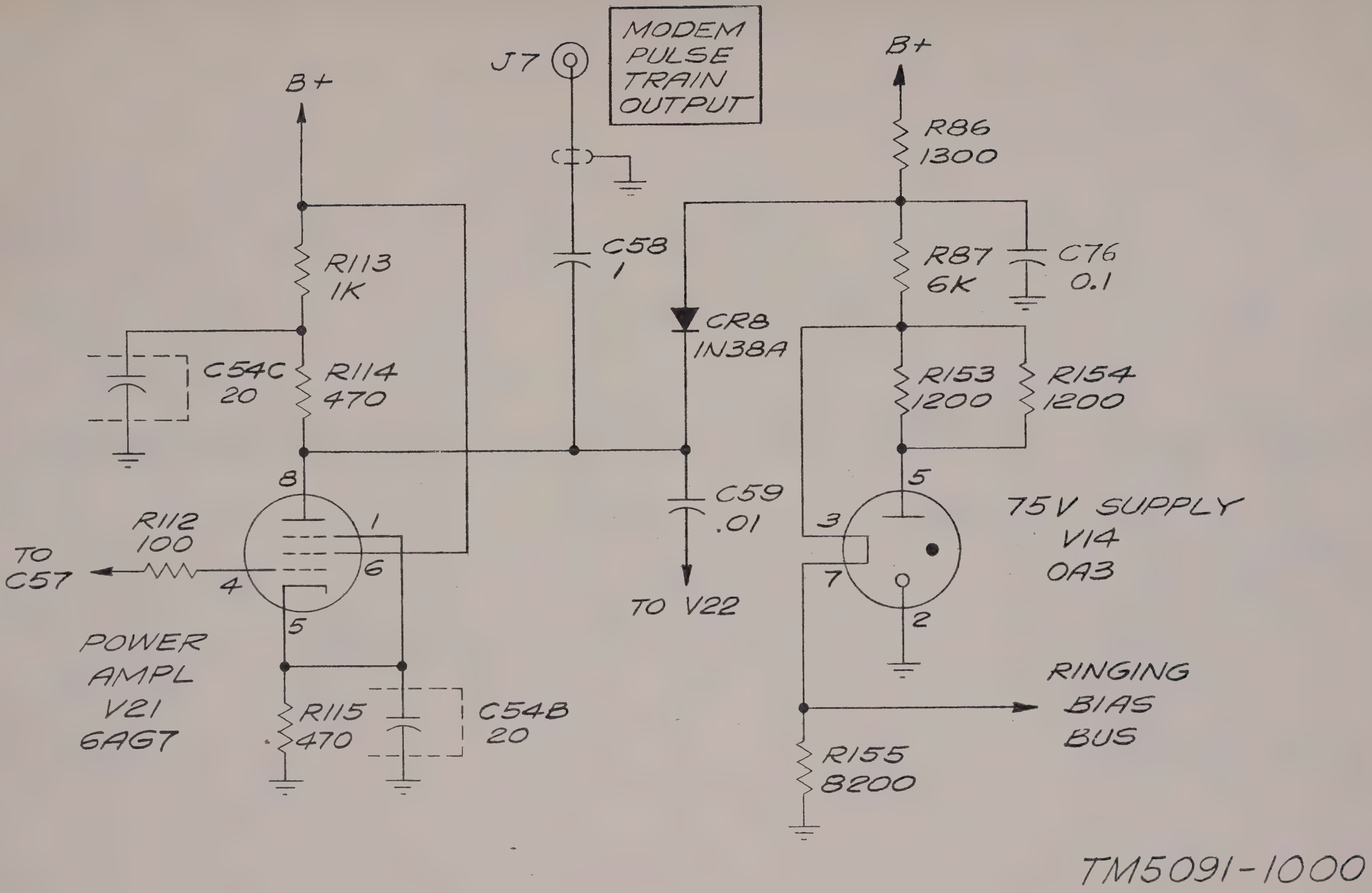

B+
R113
1K
C54C
20
R114
470
8
R112
100
TO
C57
4
1
6
5
POWER
AMPL
V21
6AG7
R115
470
C54B
20
J7
MODEM
PULSE
TRAIN
OUTPUT
C58
1
CR8
IN38A
C59
.01
TO V22
B+
R86
1300
R87
6K
C76
0.1
R153
1200
R154
1200
5
3
7
2
75V SUPPLY
V14
OA3
RINGING
BIAS
BUS
R155
8200
TM5091-1000

FIGURE 115.1. RINGING CIRCUIT SIMPLIFIED SCHEMATIC DIAGRAM

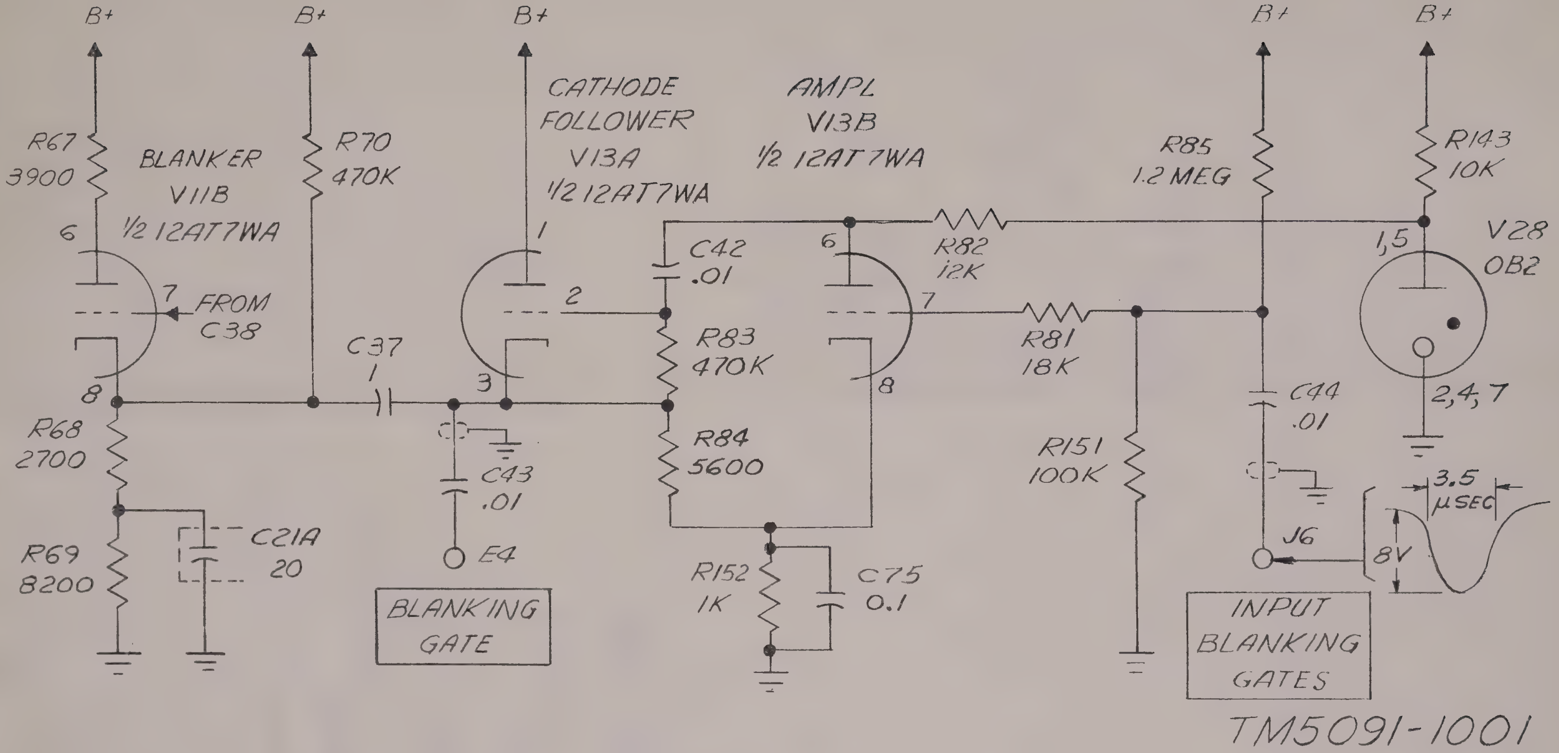

B+
B+
B+
B+
B+
R67
3900
BLANKER
V11B
1/2 12AT7WA
6
7
FROM
C38
8
R70
470K
C37
1
R68
2700
R69
8200
C21A
20
CATHODE
FOLLOWER
V13A
1/2 12AT7WA
1
2
3
C43
.01
E4
BLANKING
GATE
AMPL
V13B
1/2 12AT7WA
C42
.01
R83
470K
R84
5600
6
7
8
R152
1K
C75
0.1
R82
12K
R81
18K
R151
100K
R85
1.2 MEG
C44
.01
J6
INPUT
BLANKING
GATES
R143
10K
V28
0B2
1,5
2,4,7
3.5
μSEC
8V
TM5091-1001

FIGURE 132.1 BLANKING CIRCUIT SIMPLIFIED SCHEMATIC DIAGRAM

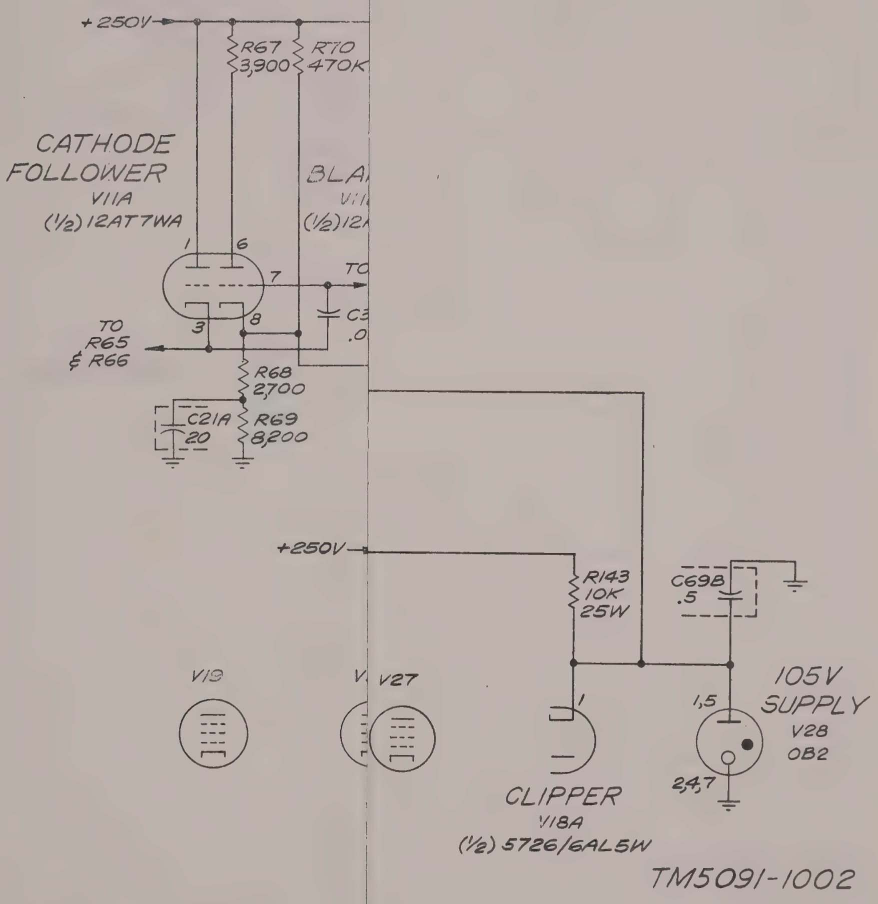

+250V
R67
3,900
R70
470K
CATHODE
FOLLOWER
V11A
(½) 12AT7WA
BLA
V11
(½) 12
1
6
7
TO
C3
.0
3
8
TO
R65
& R66
R68
2,700
C21A
20
R69
8,200
+250V
R143
10K
25W
C69B
.5
V19
V
V27
1
1,5
105V
SUPPLY
V28
OB2
2,4,7
CLIPPER
V18A
(½) 5726/6AL5W
TM5091-1002

FIGURE 260.1 VIDEO RESTORER, PARTIAL SCHEMATIC

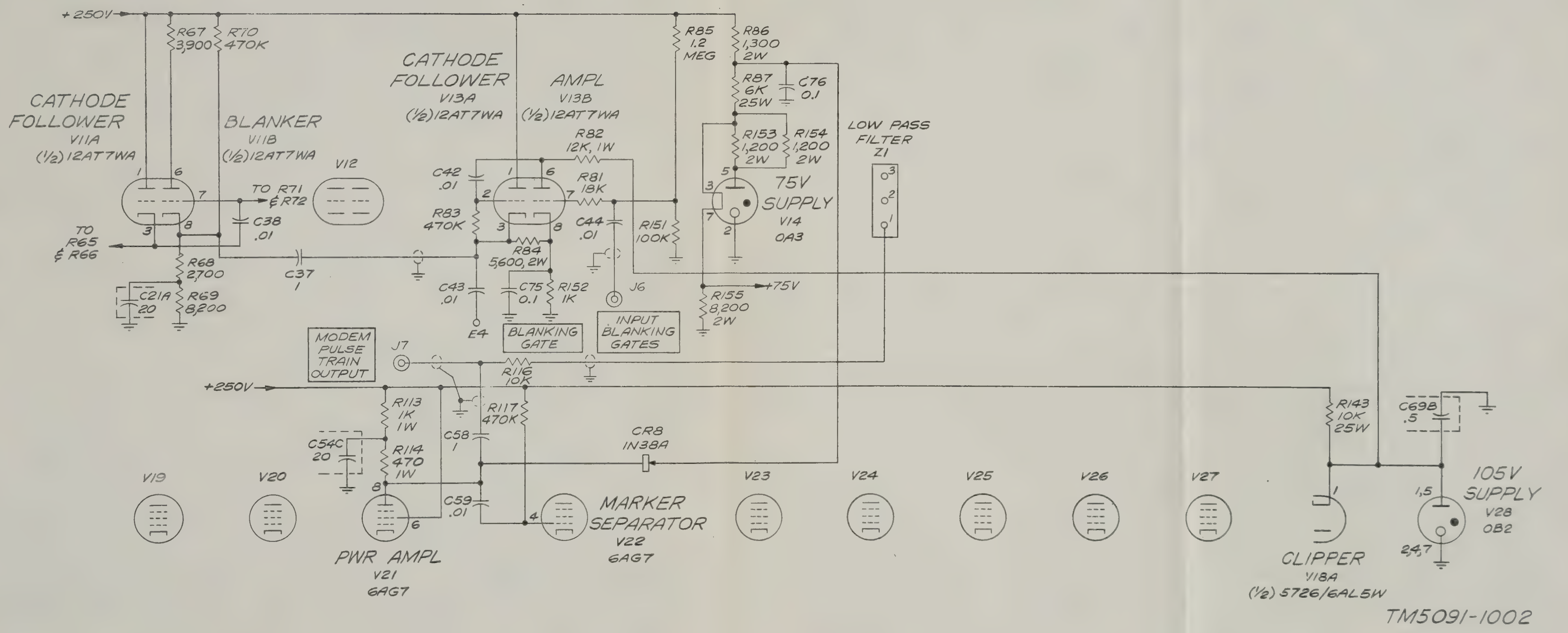

+250V
R67
3,900
R70
470K
CATHODE
FOLLOWER
V11A
(½) 12AT7WA
BLANKER
V11B
(½) 12AT7WA
V12
TO R71
& R72
C38
.01
TO
R65
& R66
R68
2,700
C21A
20
R69
8,200
C37
1
CATHODE
FOLLOWER
V13A
(½) 12AT7WA
AMPL
V13B
(½) 12AT7WA
R82
12K, 1W
R81
18K
C42
.01
R83
470K
R84
5,600, 2W
C44
.01
C43
.01
C75
0.1
R152
1K
E4
BLANKING
GATE
J6
INPUT
BLANKING
GATES
R85
1.2
MEG
R151
100K
R86
1,300
2W
R87
6K
25W
C76
0.1
R153
1,200
2W
R154
1,200
2W
75V
SUPPLY
V14
OA3
R155
8,200
2W
+75V
LOW PASS
FILTER
Z1
MODEM
PULSE
TRAIN
OUTPUT
J7
R116
10K
+250V
R113
1K
1W
R117
470K
C58
1
C54C
20
R114
470
1W
C59
.01
CR8
IN38A
V19
V20
PWR AMPL
V21
6AG7
MARKER
SEPARATOR
V22
6AG7
V23
V24
V25
V26
V27
R143
10K
25W
C69B
.5
CLIPPER
V18A
(½) 5726/6AL5W
105V
SUPPLY
V28
OB2
TM5091-1002

FIGURE 260.1 VIDEO RESTORER, PARTIAL SCHEMATIC

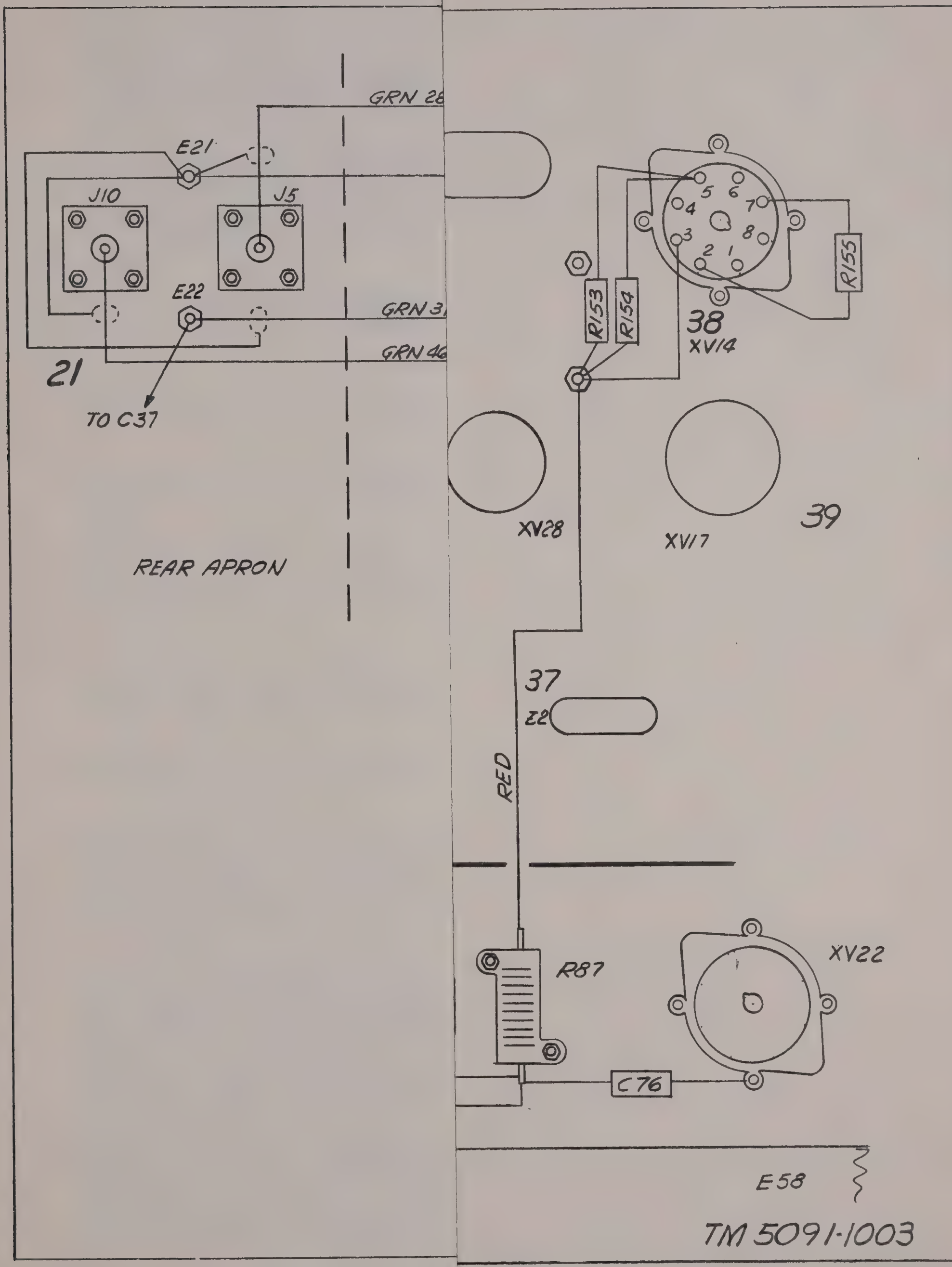

GRN 28
E21
J10
J5
E22
GRN 31
GRN 46
21
TO C37
REAR APRON
5
6
7
4
8
3
2
1
R155
R153
R154
38
XV14
XV28
XV17
39
37
Z2
RED
R87
XV22
C76
E58

FIGURE 274.1 VIDEO RESTORER, PARTIAL WIRING DIAGRAM

TM 5091-1003

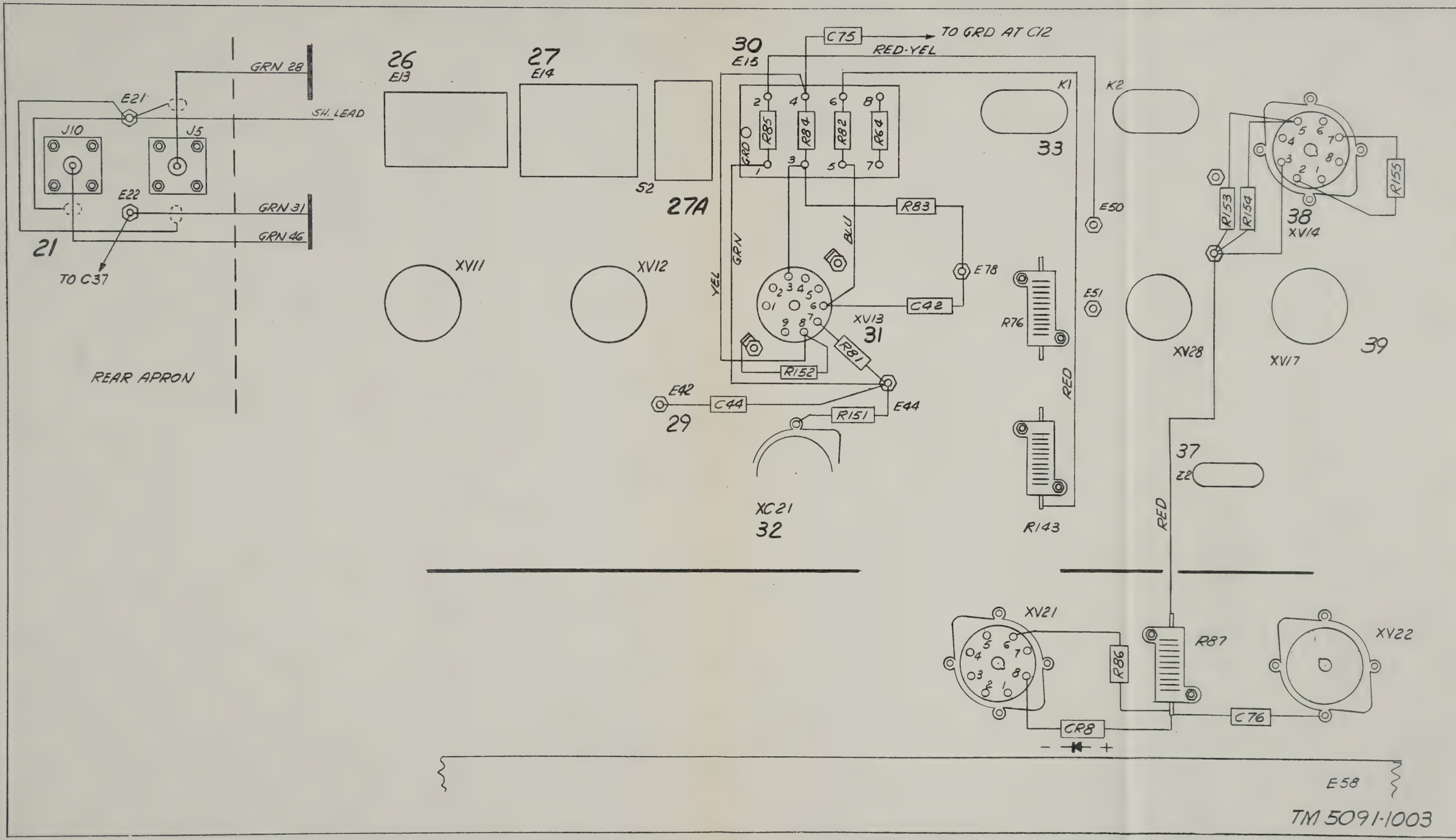

21
E21
J10
J5
E22
SH. LEAD
GRN 28
GRN 31
GRN 46
TO C37
REAR APRON
26
E13
27
E14
S2
27A
XV11
XV12
30
E15
C75
TO GRD AT C12
RED-YEL
GRD
R85
R84
R82
R64
K1
K2
33
R83
E50
E78
GRN
BLU
YEL
XV13
31
C42
R81
R152
E42
C44
E44
R151
29
XC21
32
R76
E51
R143
RED
XV28
XV17
39
R153
R154
R155
38
XV14
37
Z2
XV21
R86
R87
XV22
CR8
C76
E58
TM 5091-1003

FIGURE 274.1 VIDEO RESTORER, PARTIAL WIRING DIAGRAM

ing of 0 dbm for four-wire or a reading of –3 dbm for two-wire is obtained on the audio test set.

(*e*) *Alignment, channels 4 through 8.* Repeat the procedures given in subparagraph *c*(1) through (4) above for channels 4 through 8.

(*f*) *Westfacing alignment.* Repeat the procedures given in subparagraph *c*(1) through (5) above for the other direction of transmission (west).

(4) *Alignment of channels 3 through 8 from repeater AN/TCA–1 to terminal.*

(*a*) *At repeater AN/TCA–1.*

1. Set the control monitor test switch S1 in the SEND position.

2. Place the channel 3 eastfacing D&I-THRU switch in the D&I position.

3. Turn the eastfacing channel 3 modem selector switch S2 to the SR position.

(*b*) *At east terminal AN/TCC–13.*

1. Set the control monitor test switch S1 in the REC position.

2. Turn the channel 3 modem selector switch S2 to the RR position.

(*c*) *At repeater AN/TCA–1.* At repeater AN/TCA–1, modulate the eastfacing channel 3 with full modulation (–4 dbm for four-wire or 0 dbm for two-wire).

(*d*) *At east terminal AN/TCC–13.* At east terminal AN/TCC–13, adjust the channel 3 modem OUTPUT AUDIO GAIN control until a reading of 0 dbm for four-wire or a reading of –3 dbm for two-wire is obtained on the audio test set.

(*e*) *Alignment, channels 4 through 8.* Repeat the procedures given in subparagraph *k*(4)(*a*) through (*d*) above for channels 4 through 8.

(*f*) *Westfacing alignment.* Repeat the procedures given in subparagraph *k*(4)(*a*) through (*e*) above for the other direction of transmission (west).

Note. As a final check of circuit operation, talk and ring from the repeater to first the east and then the west terminals on all channels with a Telephone EE–8–B connected to the 2W LINE binding posts (alongside the delay line).

l. Checking Modulation of Channels. Check the modulation of the channels as follows:

(1) Calibrate the test set as described in subparagraph *d* above.

(2) Depress the control monitor SEND switch, set the test set SEND-DBM control to the 0 position, and depress the test set MEASURE F1A pushbutton switch.

(3) With the test switch on eastfacing modem 1 in the SR position, check to see if the modulation on eastfacing channel 1 is approximately ±.5 microsecond, as follows:

(*a*) Turn on the oscilloscope timing markers by rotating the TIMING PIP PHASE clockwise from the OFF position.

(*b*) Set the oscilloscope COARSE control to the 5-microsecond position and the FINE control to the 1-microsecond position.

(*c*) Rotate the FINE control until two consecutive timing pips are 10.4 centimeters (10.4 boxes) apart on the oscilloscope cathode-ray tube. The sweep speed is now .5 microsecond per centimeter.

(*d*) Place the oscilloscope probe in the OUTPUT TO EASTFACING XMTR test jack on the video restorer. The channel 1 pulse should move 1 centimeter (±.5 microsecond) from leading edge to leading edge.

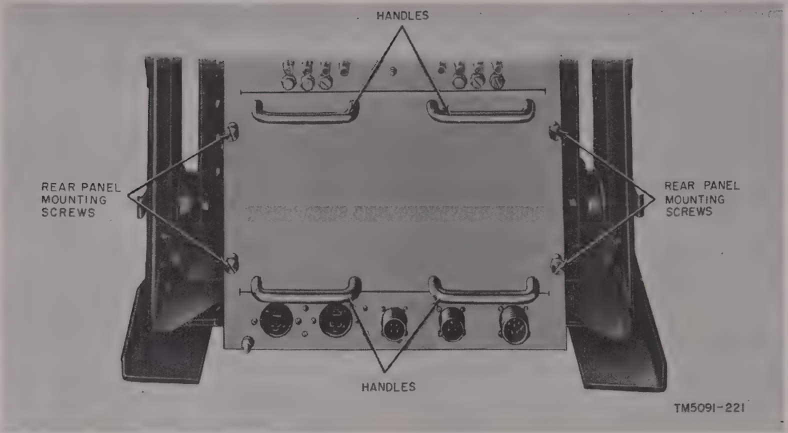

HANDLES
REAR PANEL MOUNTING SCREWS
REAR PANEL MOUNTING SCREWS
HANDLES
TM5091-221

Figure 46. Rear view of filament supply showing handles and mounting screws.

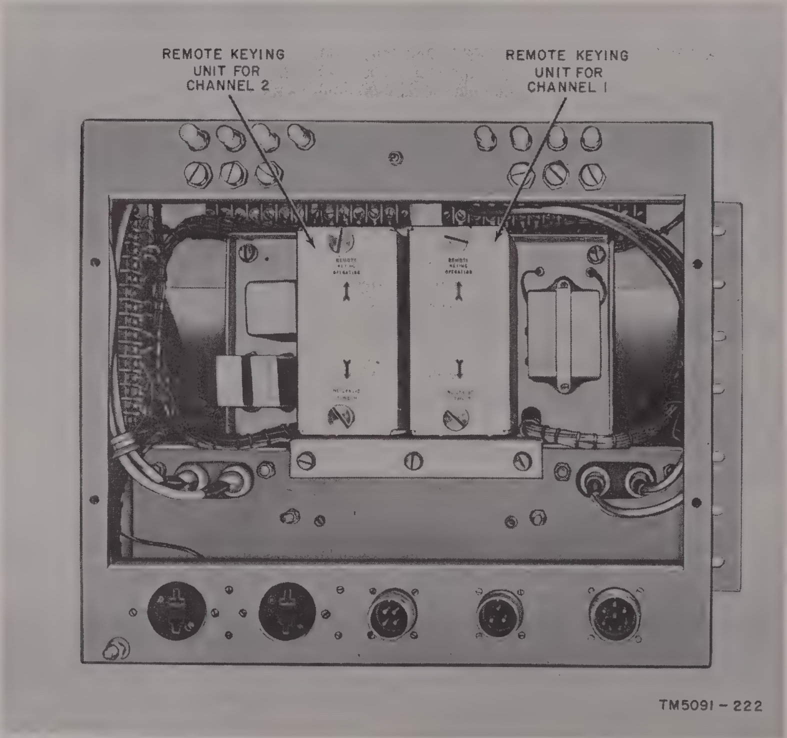

REMOTE KEYING UNIT FOR CHANNEL 2
REMOTE KEYING UNIT FOR CHANNEL 1
TM5091 - 222

Figure 47. Rear view of filament supply, rear cover removed, showing remote keying units inserted for remote keying operation.

(4) Return the test switch on eastfacing modem 1 to the OPER position, and repeat the procedures given in subparagraph (3) above for all other eastfacing modems.

(5) Repeat the procedures given in subparagraphs (1) through (4) above for the westfacing channels. However, place the oscilloscope in the OUTPUT TO WESTFACING XMTR test jack.

56. Installation Adjustment Procedure for Remote Keying Operation

a. Perform all the installation adjustment procedures described in paragraph 55.

b. In addition to the usual audio connections (modem connected in four-wire, external audio connections in two-wire), connect the remote vhf stations to the channel 1 and channel 2 remote keying binding posts, above the rear of the filament supply (fig. 46), as follows:

(1) Connect the *keying-in* pair (pair used to operate the remote vhf station) to the appropriate channel REMOTE KEYING IN binding posts.

(2) Connect the keying out pair to the appropriate channel (one or two) REMOTE KEYING OUT binding posts.

c. Unscrew the four captive screws (fig. 46) that hold the rear cover to the filament supply and remove the cover by the four handles.

d. Remove each of the remote keying units, invert and replace them so that REMOTE KEYING OPERATION points upward (47).

e. Replace the rear cover by reversing the procedure described in subparagraph *c* above.

57. Final Connections and Stopping Procedure

a. Final Connections. When all the checks and adjustments described in paragraphs 55 and 56 have been completed, the equipment is ready for operation. No further connections or adjustments are necessary.

b. Stopping. Turn off the equipment by reversing the electrical power connections described in paragraph 54.

CHAPTER 3
OPERATION

Section I. CONTROLS AND INSTRUMENTS

Note. This section locates, illustrates, and furnishes the operator sufficient information pertaining to the various controls and instruments that are provided for the proper operation of the equipment.

58. General

Haphazard operation or improper setting of the controls may damage the electronic equipment. Therefore, it is important to know the function of every control. The actual equipment operation is discussed in paragraphs 70 through 75.

59. Video Restorer Controls
(fig. 174)

The table below lists the switches of the video restorer and gives their function. The 23 CHAN-45 CHAN switch is located at the top of the eastgoing video restorer chassis and hence the bottom of the westgoing video restorer chassis (fig. 174). The P. T. OUT AMPL switch is located in the center of the video restorer chassis and the SYM ADJ potentiometer is located at the upper left-hand corner of the eastgoing video restorer and the lower right-hand corner of the westgoing video restorer.

Control	Function
23 CHAN-45 CHAN switch (S1)	Controls filament power to negative pulse train reshaping stages. Throw to 23 CHAN position for 23-channel operation, and to 45 CHAN position for 45-channel operation.
P.T. OUT AMPL switch (S2)	Controls the output of the outgoing pulse train. In the HIGH position, the output is twice that of the LOW position.
SYM ADJ potentiometer (R33)	Controls the amplitude of the outgoing pulse train. When the equipment is operating in 45-channel system, controls the amplitude of the negative and all positive peaks.

60. Telephone Modem MD–179/TC Controls
(fig. 48)

The table below lists the modem controls and lists their functions. There are 16 modems used with the Multiplexer Group AN/TCA–1.

Control	Function
SELECTOR switch (S2)	Enables any modem to be connected to the test pair. This test pair may be connected to the test set send or receive circuits or to the control monitor handset. To maintain correct impedance, only one modem should be switched to the test pair at a time (switched off OPER). The four positions permit connection of the test pair to both the send and receive circuits of the radio side (SR and RR), as well as the send and receive circuits on the line side of the modem (SL and RL). The selector switch is arranged so that the correct connections are made whether or not the circuits are in two- or four-wire operation. *Position* — *Function* SL — Connects the test pair to permit sending a test signal to the line (for example, a switchboard). SR — Connects the test pair to permit sending a test signal to the radio (for example, Radio Set AN/TRC–29).

Control	Function
	OPER — Disconnects the test pair entirely. RR — Connects the test pair to permit receiving a signal from the radio side (normally, Radio Set AN/TRC–29). RL — Connects the test pair to permit receiving a signal from the line (for example, a switchboard). *Note.* Because the control monitor handset circuit is on a two-wire basis, it can be used with the test pair only when the desired channel is connected for two-wire operation. To talk to the radio side, the selector switch must be in RR or SR position, and to talk to the line side, the selector switch must be in SL or RL position.
OUTPUT AUDIO GAIN control (R37)	Determines the audio output level of the modem.
PULSE POSITION control (R9)	Determines the position of the generated channel pulse, with respect to the marker.
2W-4W switch (S1)	Selects two- or four-wire operation in each modem. It is mounted internally in each modem (fig. 41).

61. Multiplexer Subassembly Controls MX–1442/TC (fig. 49).

The following table lists the controls of the filament supply and indicates their functions.

Control	Function
FILAMENT ON indicator lamp (I 2)	Glows red when filament voltage is applied to the mounting rack and video restorer.
+250V ON indicator lamp (I 1)	Glows red when B+ is applied to the mounting rack and video restorer.
ALARM indicator lamp (I 4)	Glows red when an alarm condition exists.
AUDIBLE ALARM DISCONNECT push switch (S1)	When pushed momentarily, this button disconnects the alarm buzzer. The alarm circuit, however, will restore itself to operation automatically when the alarm condition has been rectified.

62. Electrical Equipment Rack MT–1433/TCA–1 Controls (fig. 42)

The table below lists the switches of the equipment rack and gives their functions.

Control	Function
PARTY LINE-PRIV switches (S1 and S2)	Determine mode of operation (party line or private) for channels 1 and 2. *Position* — *Function* PARTY LINE — Provides a telephone circuit at the repeater, which is bridged onto the channel so that personnel can converse with both terminals and/or other repeaters. PRIV — Permits personnel at the repeater to converse only with a terminal or repeater in one given direction.
D&I-THRU switches (S3 through S18)	Determine whether the channel is to be operated on a drop and insert basis or whether it will pass through the repeater. *Position* — *Function* D&I — Channel operates on a drop and insert basis. THRU — Channel passes through the repeater. However, channel pulse is reshaped.

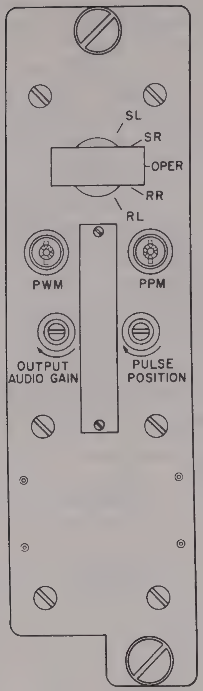


Figure 48. Telephone Modem MD–179/TC controls.

63. Oscilloscope OS–25/G Controls

(fig. 50)

The table below lists the controls of the oscilloscope and gives their functions.

<table>
<tr><th>Control</th><th>Function</th></tr>
<tr><td>ON-OFF switch (S1)</td><td>When switched to the ON position, a-c power is supplied to the oscilloscope.</td></tr>
<tr><td>POWER ON indicator lamp (I 1)</td><td>Lights when a-c power is applied to the oscilloscope.</td></tr>
<tr><td>HOR POSITION control (R139)</td><td>Turning this control clockwise or counterclockwise moves the image on the scope to the right or left.</td></tr>
<tr><td>SWEEP PHASE control (B1)</td><td>Adjusts the phase of the 8-kc synchronization signal from the video restorer.</td></tr>
<tr><td>SYNC SELECTOR switch (S3)</td><td>Permits the selection of any one of the synchronization signals.
<table>
<tr><th>Position</th><th>Function</th></tr>
<tr><td>DEMULTIPLEXER</td><td>Synchronizes on the eastgoing video restorer synchronizing (sync) output.</td></tr>
<tr><td>MULTIPLEXER</td><td>Synchronizes on the westgoing video restorer sync output.</td></tr>
<tr><td>+INT</td><td>Synchronizes on the rising edge of the signal into the vertical amplifier.</td></tr>
<tr><td>—INT</td><td>Synchronizes on the falling edge of the signal into the vertical amplifier.</td></tr>
<tr><td>+EXT</td><td>Synchronizes on the rising edge of the signal into oscilloscope EXTERNAL SYNC INPUT rear panel connector (J3).</td></tr>
<tr><td>—EXT</td><td>Synchronizes on the falling edge of the signal into EXTERNAL SYNC INPUT connector (J3).</td></tr>
</table></td></tr>
<tr><td>COARSE switch (S4)</td><td>When adjusted, it determines the approximate time for a total sweep. Four steps of 5, 50, 500, and 5,000 microseconds are provided. It is used with the FINE control (R116).</td></tr>
<tr><td>FINE control (R116)</td><td>Provides fine control of sweep duration in each range of the COARSE switch (S4).</td></tr>
<tr><td>INTENSITY control (R186)</td><td>Controls the brightness of the image on the scope screen.</td></tr>
<tr><td>FOCUS control (R187)</td><td>Controls the sharpness of the image on the scope screen.</td></tr>
<tr><td>TIMING PIP PHASE control (R150)</td><td>Moves the markers on the scope over a range of about 6 microseconds.</td></tr>
</table>

Control	Function
CAL VOLTAGE control (R35)	Used with the VERT ATTEN control (S2). It determines the amplitude of the observed wave form. When the VERT ATTEN control is in CAL position, the CAL VOLTAGE control setting is the voltage (in volts) that is applied to the input of the vertical amplifier. Refer to paragraph 55*c* for the use of these controls in determining the value of the calibrated wave form.
VERT ATTEN control (S2)	Attenuates the input signals to the vertical amplifier by the ratios shown alongside the control. *Position* *Function* 100:1 100 to 1 attenuation. 10:1 10 to 1 attenuation. 2:1 2 to 1 attenuation. 1:1 No attenuation. CAL Removes the signal that is applied to the probe and applies the calibrating voltage to vertical amplifier input.
VERT GAIN control (R68)	Increases the vertical amplitude of the scope presentation over a range of about 8 to 1.
PIP LOCKING control (R161)	Locks the pips with the pulse train.
ASTIG control (R174)	When screw-driver adjusted, it sharpens the scope presentation along the horizontal and vertical axes.
TRIGGER control (R102)	Determines the amplitude of the signal that is used to synchronize the sweep multivibrator.
STAB control (R110)	Selects either triggered or free-running operation of the sweep multivibrator.
VERT POSITION control (R180)	When turned clockwise or counterclockwise, it moves the scope presentation up or down.

64. Audio Test Set TS–762/TC Controls
(fig. 51)

The table below lists the controls of the audio test set and gives their functions.

Control	Function
SEND-DBM control (AT1)	Sets the sending level in steps of 1 dbm.
DECIBELS meter (M1)	Gives the fine reading of the received levels.
ON-OFF switch (S2)	When in the ON position, it applies power to the test set.
POWER ON indicator lamp (I 2)	Lights when power is applied to the test set.
RECEIVE-DBM control (AT2)	Attenuates the signal that is applied to the dbm meter. The actual received dbm is the algebraic sum of the setting of this control and the dbm meter reading.
ADJ SEND control (R18)	Varies the sending level for calibration.
ADJ REC control (R53)	Varies the receiving level for calibration.
CALIBRATE-MEASURE switch (S1)	The four push buttons are depressed to calibrate the test set and to measure the levels or distortion. For measuring, the test set is used with the modem selector switches (par. 59). *Position* *Function* SEND-CALIBRATE Applies send calibrating voltage to the meter. REC-CALIBRATE Applies receiver calibrating voltages to the meter. F1A-MEASURE Measures the levels with F1A line weighting on the meter. DIST AT 1000~ MEASURE Measures the distortion with 1,000-cps rejection on the meter.

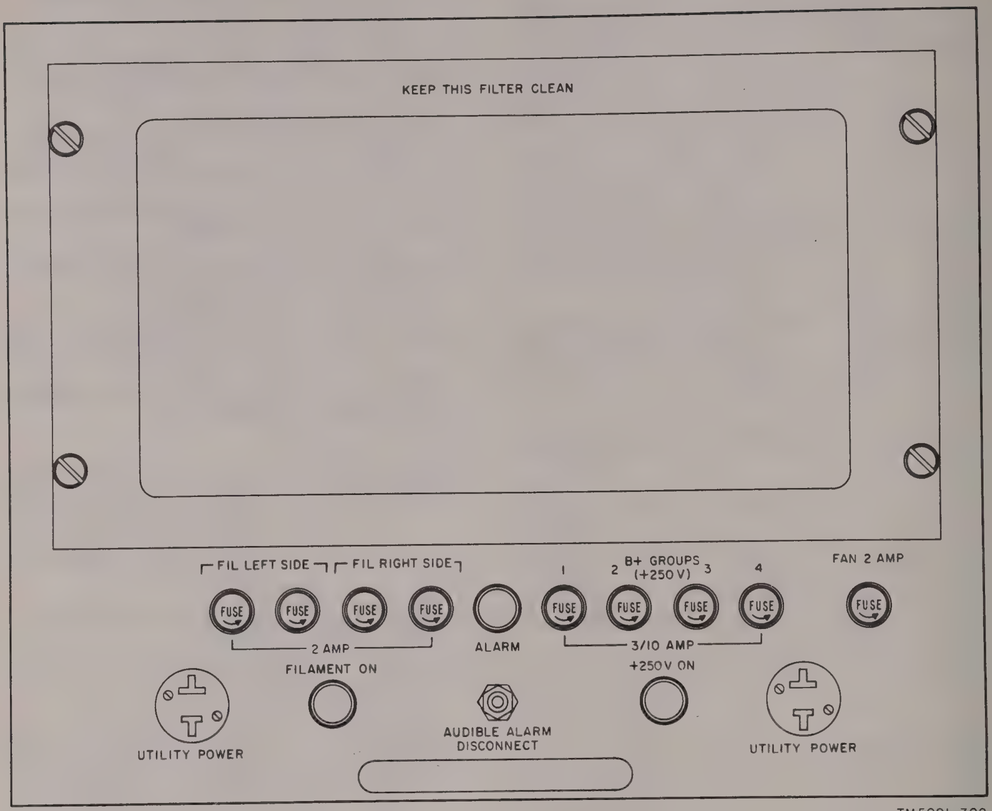
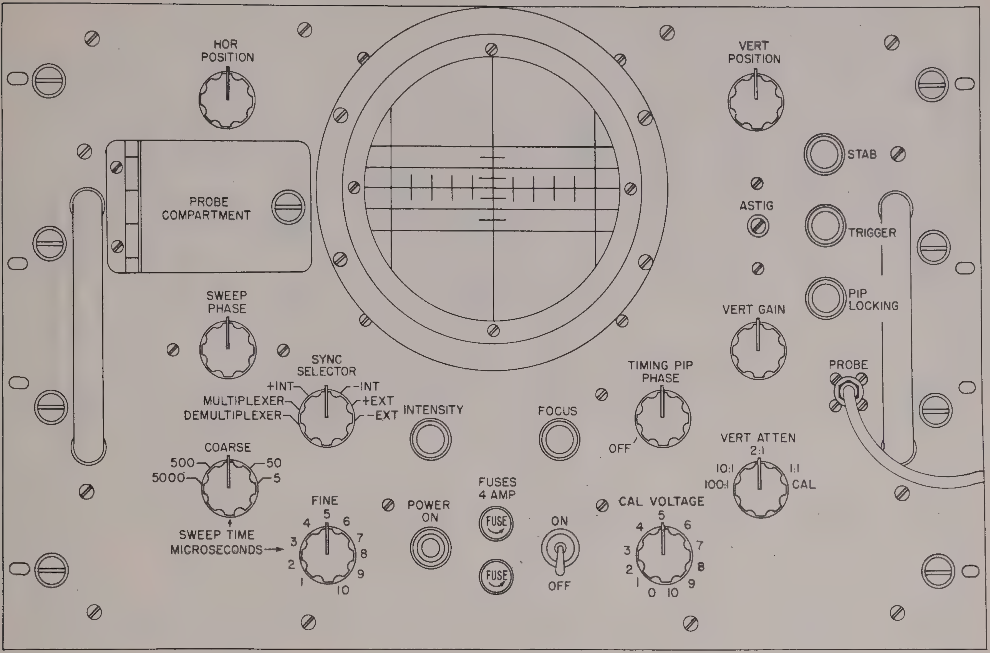

KEEP THIS FILTER CLEAN
FIL LEFT SIDE
FIL RIGHT SIDE
1
2
B+ GROUPS
(+250 V)
3
4
FAN 2 AMP
FUSE
2 AMP
ALARM
3/10 AMP
FILAMENT ON
+250V ON
AUDIBLE ALARM
DISCONNECT
UTILITY POWER
UTILITY POWER
TM 5091-302

Figure 49. Multiplexer Subassembly MX–1442/TC controls.

65. Control Monitor C–1151/TC Controls
(fig. 52)

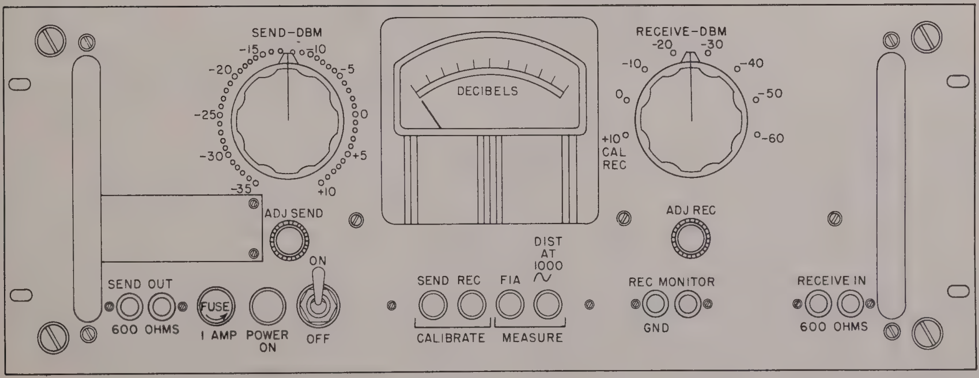
The table below lists the controls of the control monitor test panel and gives their functions.

Control	Function	
TEST PAIR switch (S1)	Controls the connections of the test pair between the modems and the test set.	
	Position	*Function*
	REC	For receiving signals, connect the test pair leads that are common to all modems to the test set.
	SEND	For sending signals, connect the modem test pair to the test set.
	TEL SET	Connects the handset to the test pair.
	NORMAL	Disconnects all testing functions from the modems.
RING switch (S2)	Applies a ringing tone to the order-wire channel (channel 1) or to the same channel to which the telephone handset is connected.	


HOR POSITION
PROBE COMPARTMENT
SWEEP PHASE
SYNC SELECTOR
+INT
-INT
MULTIPLEXER
+EXT
DEMULTIPLEXER
-EXT
INTENSITY
FOCUS
TIMING PIP PHASE
OFF
COARSE
500
50
5000
5
SWEEP TIME MICROSECONDS
FINE
1 2 3 4 5 6 7 8 9 10
POWER ON
FUSES 4 AMP
FUSE
FUSE
ON
OFF
CAL VOLTAGE
0 1 2 3 4 5 6 7 8 9 10
VERT ATTEN
2:1
10:1
1:1
100:1
CAL
VERT POSITION
STAB
ASTIG
TRIGGER
PIP LOCKING
VERT GAIN
PROBE

TM5091-303

Figure 50. Oscilloscope OS–25/G controls.


SEND-DBM
-15
-10
-20
-5
-25
0
-30
+5
-35
+10
DECIBELS
RECEIVE-DBM
-20
-30
-10
-40
0
-50
-60
+10
CAL REC
ADJ SEND
ADJ REC
SEND OUT
600 OHMS
FUSE
1 AMP
POWER ON
ON
OFF
SEND
REC
FIA
DIST AT 1000 ∿
CALIBRATE
MEASURE
REC MONITOR
GND
RECEIVE IN
600 OHMS

TM5091-304

Figure 51. Audio Test Set TS–762/TC controls.

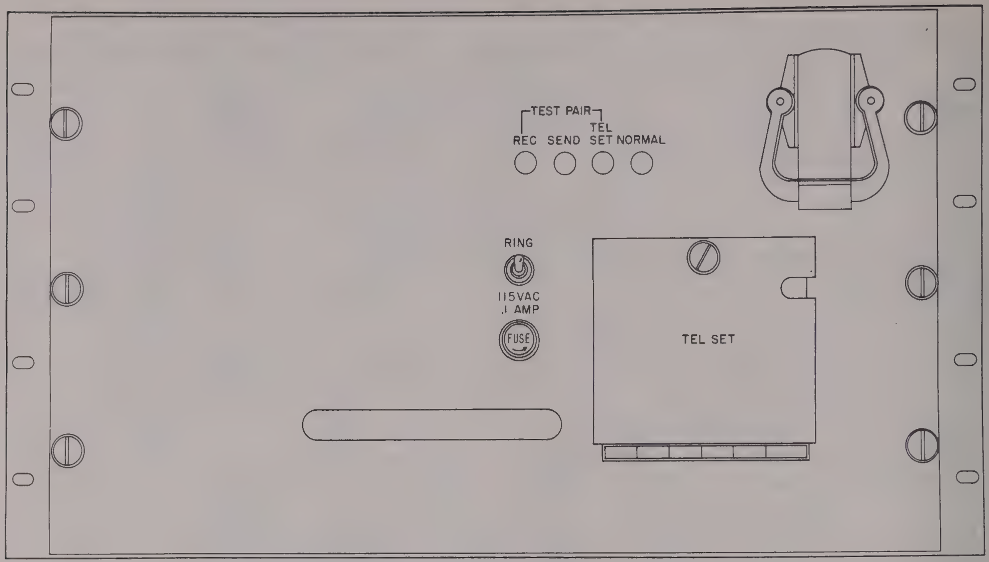

TEST PAIR
REC
SEND
TEL SET
NORMAL
RING
115VAC
.1 AMP
FUSE
TEL SET
TM5091-305

Figure 52. Control Monitor C–1151/TC controls.

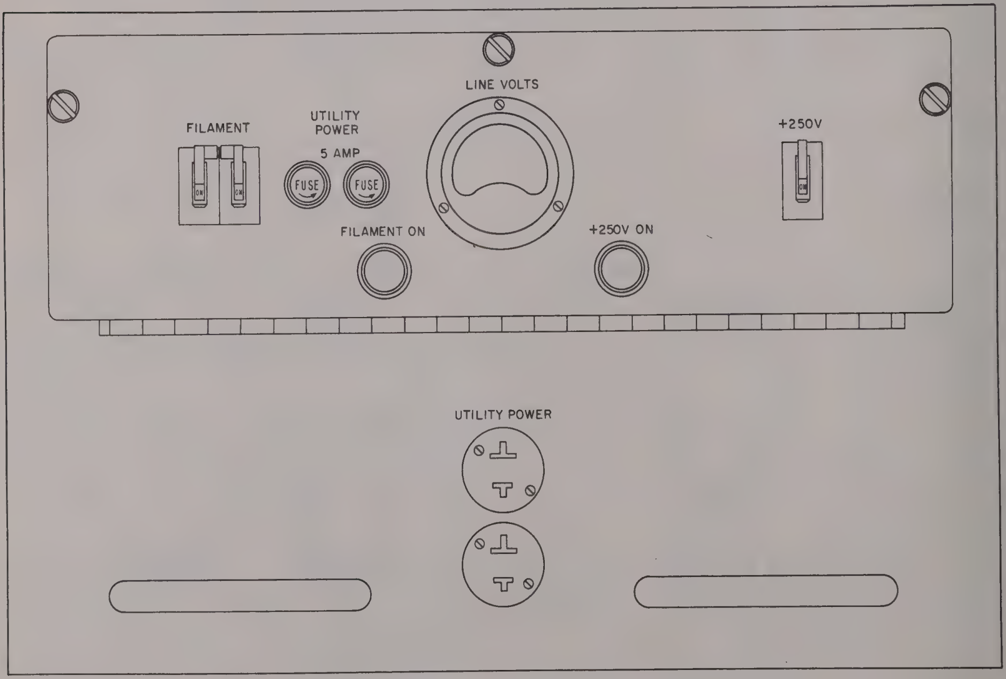
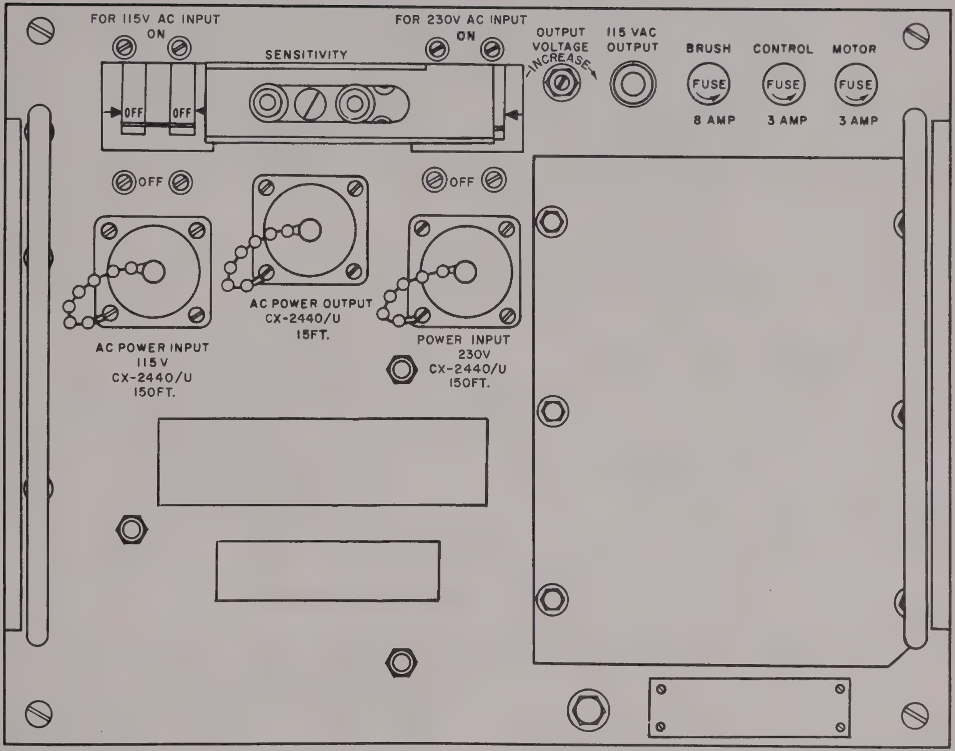

LINE VOLTS
FILAMENT
UTILITY POWER
5 AMP
FUSE
FUSE
ON
ON
+250V
ON
FILAMENT ON
+250V ON
UTILITY POWER
TM5091-306

Figure 53. Power Supply PP–691/G controls.


FOR 115V AC INPUT
ON
SENSITIVITY
FOR 230V AC INPUT
ON
OUTPUT VOLTAGE
INCREASE
115 VAC OUTPUT
BRUSH
CONTROL
MOTOR
FUSE
FUSE
FUSE
8 AMP
3 AMP
3 AMP
OFF
OFF
OFF
OFF
AC POWER INPUT
115 V
CX-2440/U
15OFT.
AC POWER OUTPUT
CX-2440/U
15FT.
POWER INPUT
230V
CX-2440/U
15OFT.

TM5091-307

Figure 54. Voltage Regulator CN–236/G controls.

66. Power Supply PP–691/G Controls

(fig. 53)

The table below lists the controls of the power supply and gives their functions.

Control	Function
FILAMENT circuit breakers (CB1 and CB2)	When switched to the ON position, filament power is applied to the multiplexer and test racks and permits a-c voltage to be applied at the utility outlets and oscilloscope and test set.
+250V circuit breaker (CB3)	In the ON position, it applies power to the power supply, which generates B+ voltage for the video restorer and mounting rack.
LINE VOLTS meter (M1)	Reads the line voltage that is applied to the power supply from the voltage regulator.
FILAMENT ON indicator lamp (I 2)	Indicates when filament power is applied.
+250V ON indicator lamp (I 1)	Indicates when B+ is applied.

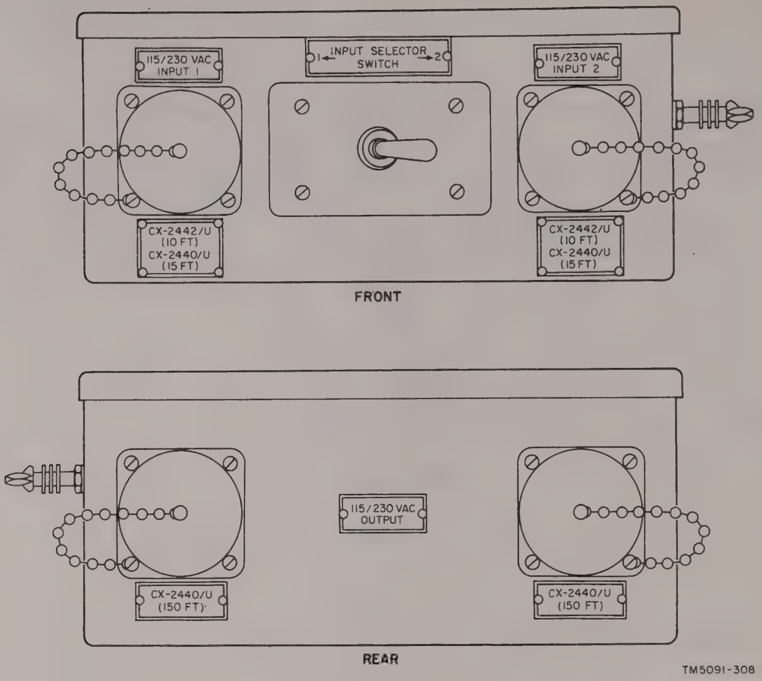

115/230 VAC INPUT 1
1 ← INPUT SELECTOR → 2
SWITCH
115/230 VAC INPUT 2
CX-2442/U (10 FT) CX-2440/U (15 FT)
CX-2442/U (10 FT) CX-2440/U (15 FT)
FRONT
115/230 VAC OUTPUT
CX-2440/U (150 FT)
CX-2440/U (150 FT)
REAR
TM5091-308

Figure 55. Switch Box SA–357/G control.

67. Voltage Regulator CN–236/G Controls
(fig. 54)

The table below lists the controls of the voltage regulator and gives their functions.

Control	Function
115V AC POWER INPUT circuit breakers (CB3 and CB4)	Applies 115-volt input to the voltage regulator from the output of the switch box.
230V AC POWER INPUT circuit breakers (CB1 and CB2)	Applies 230-volt input to the voltage regulator from the output of the switch box.
115 VAC OUTPUT indicator lamp (I 1)	Lights to indicate that output voltage is being supplied to the power supply.
OUTPUT VOLTAGE control (R11)	Adjusts the output voltage from the voltage regulator to the power supply.
SENSITIVITY control (R12)	Determines the output voltage at which the voltage regulator will correct the input voltage.

Note. To operate at 115 volts ac, move the positioning arm to the extreme right and lock. To operate at 230 volts ac, move the positioning arm to the extreme left and lock.

Caution: Always cap the unused receptacle.

68. Switch Box SA–357/G Control
(fig. 55)

The table below lists the switch box control and gives its function.

Control	Function
INPUT SELECTOR SWITCH (S1)	Selects 115/230 VAC INPUT 1 or 115/230 VAC INPUT 2. Either of two primary power sources is available for the multiplexer group by the position of the switch.

Section II. OPERATION UNDER USUAL CONDITIONS

69. General

This equipment is connected and adjusted for continuous 24-hour operation by installation and maintenance personnel; no adjustment of controls is needed by operating personnel. Paragraphs 70 and 71 describe the preliminary adjustments and starting procedures that are required for operation. Paragraph 72 describes the operation of the order-wire channel, paragraph 73 describes the operation on channels 1 and 2, and paragraph 74 describes the operation on channels 3 through 8.

70. Preliminary Adjustments

Before power is applied to the multiplexer group, set the following controls to the position shown:

Component	Control	Figure	Position
Power supply	*a.* FILAMENT circuit breaker	53	*a.* Down (off).
	b. +250V circuit breaker	53	*b.* Down (off).
Audio test set	ON-OFF switch	51	OFF.
Video restorer	23 CHAN-45 CHAN switch	174	To desired 23-channel or 45-channel position.
Modem	*a.* Selector switch	48	OPER.
	b. 2W-4W switch	40	Plug in with desired 2W (two-wire) or 4W (four-wire) mark toward arrow on terminal board.
Control monitor	TEST PAIR switch	52	NORMAL.
Voltage regulator	*a.* 115V AC POWER INPUT circuit breaker	54	*a.* Down to OFF.
	b. 230V AC POWER INPUT circuit breaker	54	*b.* Down to OFF.
Switch box	INPUT SELECTOR SWITCH	55	Throw to either position 1 or position 2, depending on the power source.
Multiplexer subassembly	Remote keying units	9	Plug in with either NORMAL OPERATION or REMOTE KEYING OPERATION pointing upward on either or both units, depending on the desired mode of operation for channels 1 and 2.
Oscilloscope	*a.* All controls except ON-OFF switch	50	*a.* Set all controls as shown in paragraph 55*b*(1).
	b. ON-OFF switch		*b.* OFF.

71. Starting Procedure

Note. If, during the starting procedure, an abnormal result is obtained, refer to the equipment performance checklist (par. 96). Refer to paragraph 70 before using this starting procedure.

a. Throw the voltage regulator 115V AC POWER INPUT circuit breaker or the 230V AC POWER INPUT circuit breaker (depending on the input voltage) to the ON position. Place the power supply FILAMENT circuit breaker in the ON position. The FILAMENT ON indicator lamps in both the power supply and multiplexer subassembly should light. The alarm will sound but can be quieted by pushing the disconnect button. The blower fan in the video restorer and multiplexer subassembly should operate. The LINE VOLTS meter in the power supply should read approximately 115 volts.

b. Wait 30 seconds for the filaments to warm up, and then throw the power supply +250V circuit breaker to the ON position. The +250V ON indicator lamps in both the power supply and multiplexer subassembly should light.

c. Turn on the test set and oscilloscope by placing their power ON-OFF switches in the ON position. The POWER ON indicator lamps in both units should light.

d. The multiplexer group is now operating.

(1) An alarm buzzer and an ALARM indicator lamp are located in the multiplexer subassembly. When there is an improper input to the video restorer, or improper operation of the demultiplexer section, or delay lines, the buzzer sounds and the ALARM lamp lights. Therefore, maintenance personnel should be informed immediately whenever the buzzer sounds and the lamp lights.

(2) To disconnect the alarm buzzer, press the AUDIBLE ALARM DISCONNECT push button on the multiplexer subassembly front panel. However, the ALARM indicator lamp will remain lighted until the trouble has been corrected.

72. Operation of Order-wire Channel

The order-wire system provides a channel (channel 1) of the multiplexer group especially for communication between the operators of the various stations, for instructions, testing purposes, trouble shooting, and other official business. To operate the order-wire channel, note the following three conditions:

a. The channel 1 D&I-THRU switch (fig. 42) must be in D&I position.

b. The channel 1 modem 2W-4W switch (fig. 41) must be in the 4W position.

c. The channel 1 PARTY LINE-PRIV switch (fig. 42) must be in the PARTY LINE position. Note that the order-wire system will not operate on channel 1 unless the PARTY LINE-PRIV switch is in PARTY LINE. To operate the order-wire channel, depress the control monitor NORMAL button (which connects the telephone handset to channel 1 on a two-wire basis) and proceed as follows:

(1) To initiate a call, press the RING button on the control monitor. The button should be pressed and released until the desired *party line* ring has been transmitted. The series of ring bursts should be transmitted several times until the called party responds.

(2) To talk, depress the switch on the telephone handset and talk into the transmitting end of the handset.

Note. The handset may be used for both talking and listening when the switch is depressed. If only reception is desired, release the switch.

(3) To receive, place the receiver portion of the handset to the ear.

Note. If the order-wire channel 1 fails, use channel 2 as the order-wire channel. To do this, proceed as follows at the repeater:

(*a*) Place the control monitor switch (fig. 43) in the NORMAL position.

(b) Place the channel 2 PARTY LINE-PRIV switch (fig. 42) in the PARTY LINE position.

(*c*) Place both the eastfacing and westfacing channel 2 D&I-THRU switches (fig. 42) in the D&I position.

(*d*) Place both the eastfacing and westfacing channel 2 2W-4W switches (fig. 41) in the 4W position.

(*e*) Connect a Telephone EE-8-B across the channel 2 PARTY LINE binding posts on the back of the electrical equipment rack (fig. 7).

(4) To ring out, crank the generator on field Telephone EE–8–B. This will apply a 20-cycle ringing voltage to the PARTY LINE binding posts, which, through a sequence of events, removes B+ from V2 in the modems. This will cause the channel 2 pulse in both directions to be blanked out. The repeater channel 2 field Telephone EE–8–B rings when the incoming channel 2 pulse is blanked out, since 20-cycle ringing voltage from the control monitor is transferred to the PARTY LINE channel 2 terminals.

(5) If neither channel 1 nor 2 is available, use any of the other channels (channels 3 through 8) for the order-wire channel. To do this, proceed as follows at the repeater (depending on the direction the operator at the repeater wants to talk to):

(*a*) Place the control monitor switch (fig. 43) in the NORMAL position.

(*b*) Place the modem 2W-4W switch (fig. 41) in the 2W position.

(*c*) Place the D&I-THRU switch (fig. 42) in the D&I position.

(*d*) Connect a Telephone EE–8–B across the 2W LINE binding posts of the desired channel (and also desired direction) at the rear of the electrical equipment rack (fig. 28).

(*e*) Place the modem selector switch (fig. 44) in the SR or RR position.

(*f*) It is now possible to talk on the desired channel and in the direction selected.

73. Operation of Channels 1 and 2

a. General. The operation of the restorer group is first determined by the position of the 23- and 45-channel selector switch, and then by the positions of the four pull-out reversible-type switches (two PARTY LINE-PRIV switches and two D&I-THRU switches).

(1) The 23 CHAN-45 CHAN selector switch (par. 60) on each video restorer chassis should be set to its correct position (for 23- or 45-channel operation).

(2) The four pull-out reversible-type switches determine the various modes of operation of the restorer group, as shown in figure 49. The THRU-D&I and PARTY LINE-PRIV switches are located behind the binding post doors (fig. 42), the NORMAL OPERATION-REMOTE KEYING OPERATION remote keying unit is located on the rear of the mounting rack (fig. 17), and the 2W-4W switch is located inside the modem (fig. 39).

b. Through Operation. With the two applicable channel 1 and/or 2 D&I-THRU switches (two for each channel, one for each direction) in the THRU position (THRU on top), the restorer group will simply receive, reshape, and retransmit the received pulse train. No drop and insert facility is available.

c. Drop and Insert Operation. With the applicable channel 1 and/or 2 D&I-THRU switch in the D&I position, the drop and insert facility of the restorer group is available, using either normal or remote keying operation.

(1) *Normal operation.* With the applicable channel 1 and/or 2 remote keying unit in the NORMAL OPERATION position, the normal drop and insert operation is available to permit local access to the v-f channels. Under this condition it is possible to operate either party line or private.

(*a*) *Party-line operation.* With the PARTY LINE-PRIV switch in the PARTY LINE position, party-line operation is possible. Party-line operation provides a telephone circuit at the repeater station, which is bridged onto the given channel so that personnel on the telephone circuit can converse with both terminals and/or other repeaters

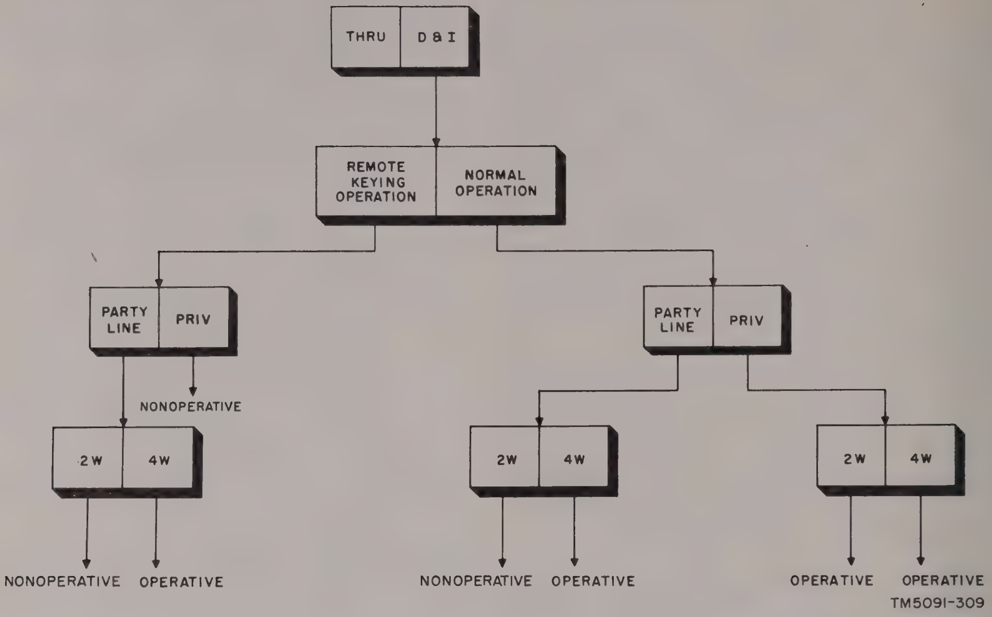

THRU
D & I
REMOTE KEYING OPERATION
NORMAL OPERATION
PARTY LINE
PRIV
NONOPERATIVE
PARTY LINE
PRIV
2W
4W
2W
4W
2W
4W
NONOPERATIVE
OPERATIVE
NONOPERATIVE
OPERATIVE
OPERATIVE
OPERATIVE
TM5091-309

Figure 56. Operational switches (channels 1 and 2), block diagram.

(when also connected for party-line operation). When operating on party line (in normal operation), the modem 2W-4W switch must be in the 4W position. Note that although each modem of the given channel is connected for 4W output, the party-line circuit is always two-wire.

(*b*) *Private operation.* With the PARTY LINE-PRIV switch in the PRIV position, private operation is possible. Private operation is the opposite of party-line operation—that is, a telephone circuit at a repeater station connected for private operation will permit personnel on the telephone circuit to converse only with a terminal or repeater in one given direction. When operating under private operation (in normal operation), it is possible to use the input telephone circuit on either a two- or four-wire basis, provided the modem 2W-4W switch is properly positioned.

Note. Since in private operation the eastfacing and westfacing circuits are independent, separate circuits to the east and west terminals are available on each channel simply by connecting two field telephones to the proper eastfacing and westfacing binding posts on the rear of the mounting rack.

(2) *Remote keying operation.* With the applicable channel 1 and/or 2 remote keying unit in REMOTE KEYING OPERATION position, the complete remote keying facility as described in paragraph 45 is provided. However, under this condition the PARTY LINE-PRIV switch must be in the PARTY LINE position, and the modem 2W-4W switch must be in the 4W position, as shown in figure 56. Audio connections are made to party-line terminals on a two-wire basis.

74. Operation of Channels 3 through 8

Since there are no remote keying switches or PARTY LINE-PRIV switches for channels 3 through 8, operation on these channels can only be on either a THRU or D&I (PRIV) basis (channels 3 through 8 are automatically wired for private operation). Operation of these channels for either THRU or D&I (private) is exactly as described in paragraphs 73*b* and 73*c*(1)(*b*) above.

75. Stopping Procedure

a. Normal Shut-down Procedure.

(1) Before shutting down the equipment, notify the telephone control operator and the operators at the other stations that the equipment is being shut down. Use the order-wire channel for communication.

(2) Turn the oscilloscope INTENSITY control to the extreme counterclockwise position.

(3) Turn the oscilloscope and audio test set power switches to the OFF position.

(4) Turn the +250V switch on the power supply to the OFF position.

(5) Turn the FILAMENT switch on the power supply to the OFF position.

(6) Throw the voltage regulator 115V AC POWER INPUT circuit breaker or 230V AC POWER INPUT circuit breaker (whichever is in use) to the OFF position.

(7) Remove the auxiliary equipment plugs from the utility outlets where the auxiliary equipment was in temporary use.

b. Emergency Shut-down Procedure. To shut down the equipment in an emergency, throw the power supply FILAMENT circuit breaker to OFF. Remove any auxiliary equipment plugs from the utility outlets, if required.

c. Bypassing Effects on System Operation. Since the alarm circuit contains a bypassing feature and is of the normally energized type, both video restorers will be bypassed and system operation will be maintained. Bypassing, however, introduces approximately a 6-db loss in the output pulse train amplitude. While this is not serious for emergency operation, it should not be left in this condition for prolonged periods. If a shut-down of several hours or days is contemplated, the multiplexer group should be bypassed manually by connecting the eastfacing radio-frequency (r-f) receiver directly to the westfacing r-f transmitter, etc., to provide a pure repeater arrangement.

Section III. OPERATION UNDER UNUSUAL CONDITIONS

76. General

The operation of Multiplexer Group AN/TCA–1 may be difficult in regions where extreme cold, heat, humidity, moisture, and similar conditions prevail. While every precaution is taken in the equipment design to maintain its technical characteristics over a wide temperature and humidity range, adverse conditions may cause equipment failure unless additional precautions are taken. Paragraphs 77 through 79 outline procedures that minimize the effects of these unusual climatic conditions.

77. Operation in Arctic Climates

Subzero temperatures and climatic conditions associated with cold weather affect the efficient operation of the equipment. Instructions and precautions for operations under such adverse conditions follow:

a. Handle the equipment carefully.

b. Keep the equipment warm and dry. If the set is not in a heated inclosure, operate it with the transit case covers partially covering it.

c. If possible, place the equipment inside a heated inclosure where there is no danger of a cold draft striking the glass tubes when a door is opened. A sudden draft of cold air is often sufficient to shatter the glass envelope of a heated tube. If the inclosure is so constructed that this precaution is impossible, place a blanket or some barrier between the source of the draft and the equipment. A 4-hour warm-up with the B+ voltage off is recommended at temperatures below –20°F.

d. Heavy coatings of frost will gather on the mouthpiece of the telephone handset in extreme cold weather when the telephone is used outdoors or in a cold room. Frost from the breath will form in the small holes of the cap and affect the output of the telephone. Plastic covers have been designed to protect some types of telephones; use them if available.

e. If water or moisture gets into the telephone receiver, it may freeze and impede the action of the diaphragm. If this happens, unscrew the bakelite cap and remove the ice and moisture.

f. In cold weather, the values of the filter capacitors in the power supply may drop and the output voltage may drop. If this condition occurs, change the taps on power transformer T1 in the power supply from tap 5 to tap 6, and from tap 4 to tap 3. This will raise the output voltage to compensate for the drop caused by cold weather.

78. Operation in Tropical Climates

When operated in tropical climates, the multiplexer group may be installed in tents, huts, and in swampy areas. When equipment is installed in swampy areas, it is subjected to moisture conditions more acute than those that are normal in the tropics. Ventilation is usually very poor, and the high relative humidity causes moisture condensation on the equipment whenever its temperature becomes lower than the surrounding air. To minimize this condition, place lighted electric bulbs under or near the equipment.

79. Operation in Desert Climates

a. Conditions similar to those encountered in tropical climates often prevail in desert areas. Use the same measures to insure proper equipment operation.

b. The main problem that arises with equipment operation in desert areas is the large amount of sand, dust, or dirt that enters the moving parts of the radio equipment, such as the blower motors and power units. The ideal preventive precaution is to house the equipment in a dustproof shelter. Because such a building is seldom available and would require air conditioning, the next best precaution is to make the building in which the equipment is located as dustproof as possible with available materials. Hang wet sacking over the windows and doors, cover the inside walls with heavy paper, and secure the side walls of tents with sand to prevent their flapping in the wind.

c. Never tie power cords, signal cords, or other wiring connection to either the inside or the outside of tents. Desert areas are subject to sudden wind squalls, which may jerk the connections loose or break the lines.

d. Try to keep the equipment as free from dust as possible. Make frequent preventive maintenance checks (par. 86). Clean the filter in the filament power supply frequently.

CHAPTER 4
ORGANIZATIONAL MAINTENANCE

Section I. ORGANIZATIONAL TOOLS AND EQUIPMENT

80. General

a. The tools, materials, or tool equipment kits that are furnished with the equipment are described in paragraph 81. Additional tools and test equipment are supplied with Radio Set AN/TRC–29.

b. The actual allowable organizational maintenance that can be performed depends on the existing tactical situation and on the tools and other test equipment that are issued.

c. Test equipment that is recommended for issue but not supplied with Multiplexer Group AN/TCA–1 follows:

Tester TV–7/U

1 Electronic Multimeter TS–505/U

1 Multimeter TS–297/U

81. Tools and Materials Required for Multiplexer Group AN/TCA–1

The following list of tools and materials are not furnished as part of the multiplexer group. They are required for organizational maintenance.

a. Tools.

1 Tool Equipment TE–41

b. Materials.

Cheesecloth, bleached lint-free[1]

Carbon tetrachloride[1]

Orange stick

Paper, sand, flint #000[1]

Solvent, Dry Cleaning (SD) (Fed. spec No. P-S-661a)

[1] Part of Tool Equipment TE–41.

82. Special Tools Supplied with Multiplexer Group AN/TCA–1

Special tools supplied with the equipment are located in Accessories Case CY–1334/G (fig. 12). To gain access to the tools, loosen the two thumbscrews and pull out the drawer.

a. Tube Pin Straighteners. Two tube pin straighteners are supplied with the equipment. One is used with 7-pin miniature tubes and the other is used with 9-pin miniature tubes.

b. Tube Pullers. Two tube pullers are supplied with the equipment, one for extracting the 7-pin miniature tubes and the other for extracting the 9-pin miniature tubes.

c. Wrenches. A number 6 and number 8 wrench are supplied for use with the equipment.

Section II. PREVENTIVE MAINTENANCE

83. Definition of Preventive Maintenance

Preventive maintenance is work performed on equipment (usually when the equipment is not in use) to keep it in good working order so that breakdowns and needless interruptions in service will be kept to a minimum. Preventive maintenance differs from trouble shooting and repair since its object is to prevent certain troubles from occurring.

84. General Preventive Maintenance Techniques

a. Use #000 sandpaper to remove corrosion. corrosion.

b. Use a clean, dry, lint-free cloth or a dry brush for cleaning.

(1) If necessary, except for electrical contacts, moisten the cloth or brush with solvent (SD) ; then wipe the parts dry with the cloth.

(2) Clean electrical contacts with a cloth moistened with carbon tetrachloride; then wipe them dry with a cloth.

> ***Caution:*** Repeated contact of carbon tetrachloride with the skin or prolonged breathing of the fumes is dangerous. Make sure adequate ventilation is provided.

c. If available, dry compressed air may be used at a line pressure not exceeding 35 pounds per square inch to remove dust from inaccessible places. Be careful, however, or mechanical damage from the air blast may result. Wear goggles or close the eyes while the air blast is on to prevent foreign particles from entering the eyes.

Caution: When using compressed air, always direct the first blast of the air line toward the floor. This procedure is necessary to clear condensed moisture from the line.

d. For further information on preventive maintenance techniques, refer to TB SIG 178, Preventive Maintenance Guide For Radio Communication Equipment.

85. Use of Preventive Maintenance Forms

(fig. 57 and 58)

The information in paragraph 86 is a guide to the individual inspecting the equipment in accordance with instructions on DA Form 11-238 and DA Form 11-239. The decision as to which items on the forms are applicable to this equipment is a tactical decision to be made in the case of the first echelon maintenance by the communication officer/chief or his designated representative, and in the case of second and third echelon maintenance, by the individual making the inspection. Instructions for the use of each form appear on the reverse side of the form.

86. Performing Preventive Maintenance

Caution: Tighten screws, bolts, and nuts carefully. Fittings tightened beyond the pressure for which they are designed will be damaged or broken.

a. Exterior Items.

(1) Check for completeness and general condition of the multiplexer group. The major components are listed in paragraph 8.

(2) Check suitability of location and installation for normal operation.

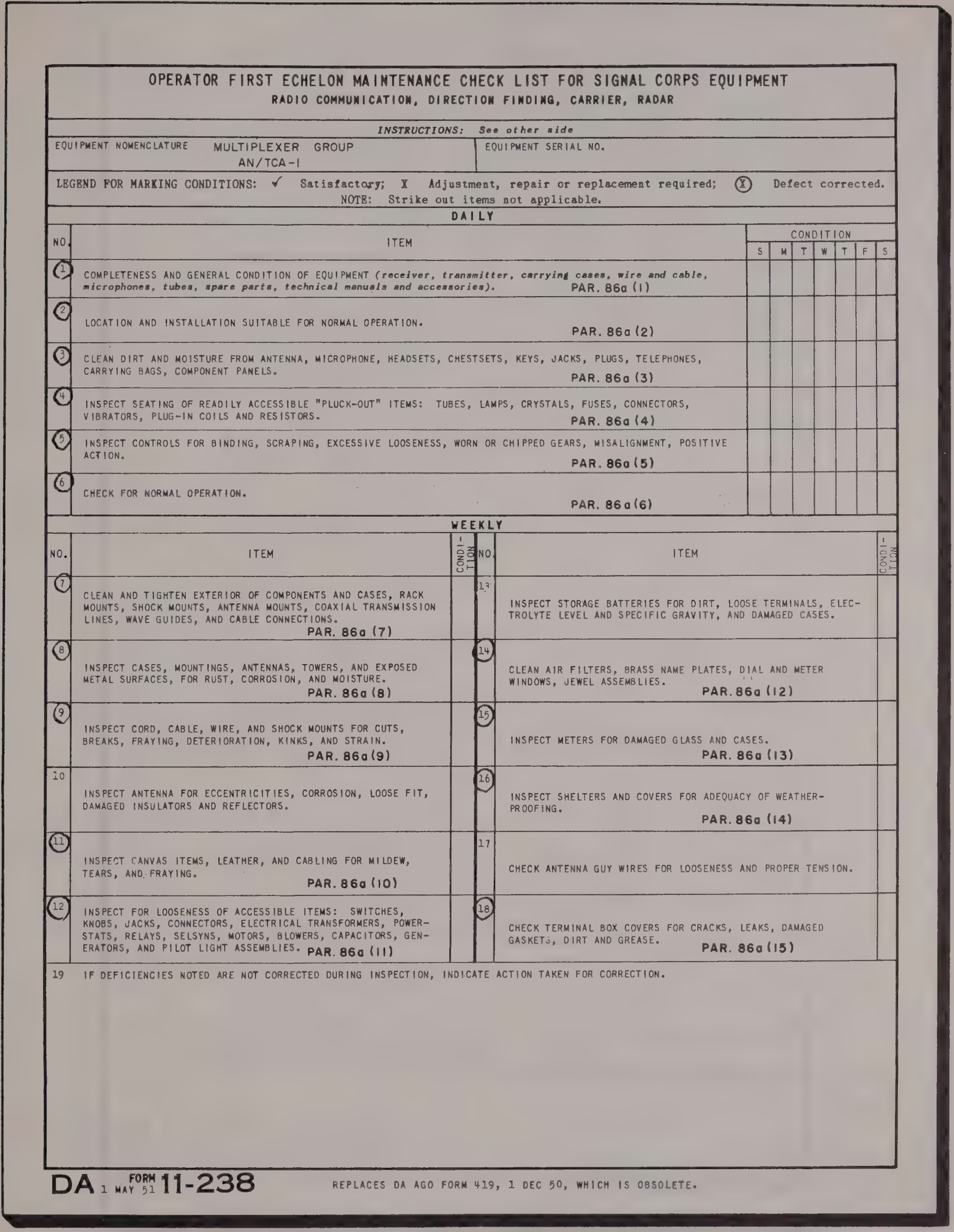
(3) Remove dirt and moisture from the multiplexer subassembly filter, handset, jacks, plugs, and panels of the component parts.

(4) Inspect all plugs and connectors. Inspect the seating of fuses, and D&I-THRU and PARTY LINE-PRIV switches.

(5) Inspect all dials and controls for binding, scraping, excessive looseness, worn or broken indicators.

(6) Check for normal operation of all operating components.

(7) Clean and tighten the exterior of all components and cases, the equipment rack shock mounts, cable connections, and rack slides.



OPERATOR FIRST ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT
RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE MULTIPLEXER GROUP AN/TCA-1

EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; Ⓧ Defect corrected.
NOTE: Strike out items not applicable.

DAILY

NO.	ITEM	CONDITION S	M	T	W	T	F	S
①	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT *(receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories).* PAR. 86a (1)							
②	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. PAR. 86a (2)							
③	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS. PAR. 86a (3)							
④	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS. PAR. 86a (4)							
⑤	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION. PAR. 86a (5)							
⑥	CHECK FOR NORMAL OPERATION. PAR. 86a (6)							

WEEKLY

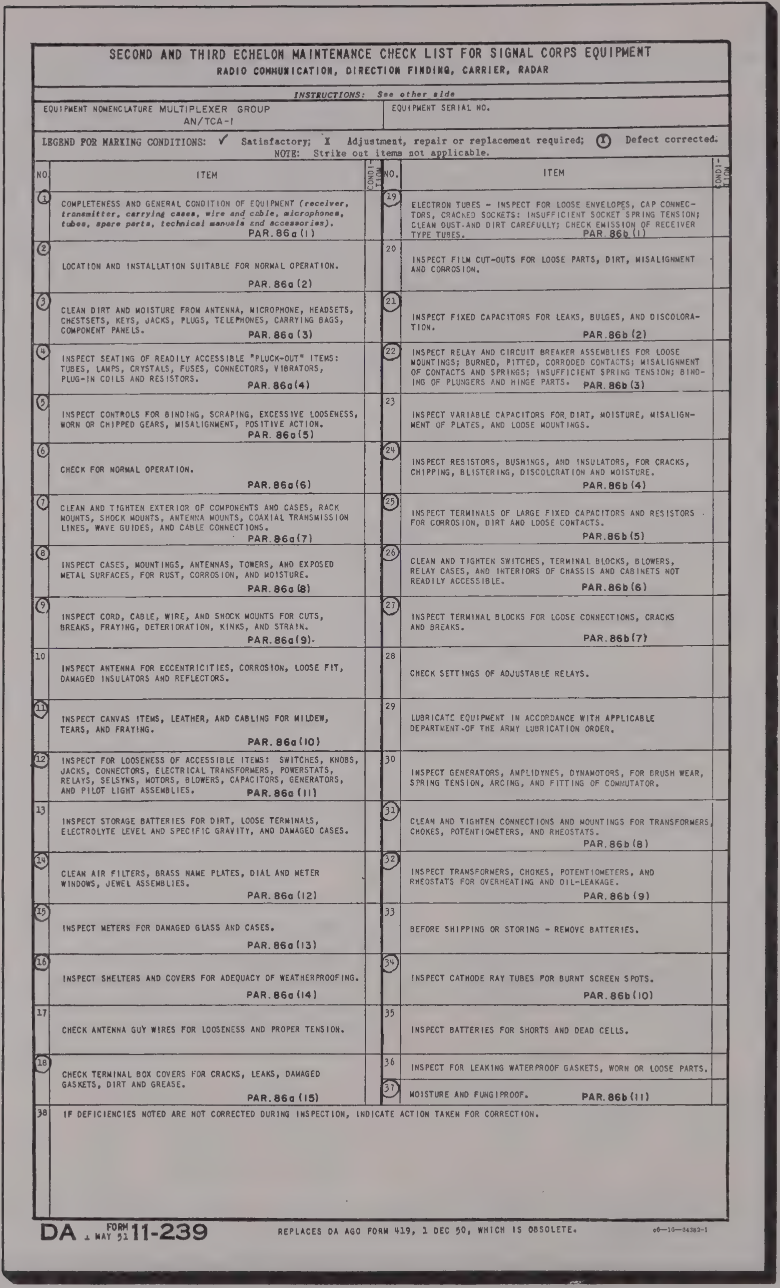
NO.	ITEM	CONDITION	NO.	ITEM	CONDITION
⑦	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS. PAR. 86a (7)		13	INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.	
⑧	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 86a (8)		⑭	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES. PAR. 86a (12)	
⑨	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 86a (9)		⑮	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR. 86a (13)	
10	INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.		⑯	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING. PAR. 86a (14)	
⑪	INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING. PAR. 86a (10)		17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.	
⑫	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES. PAR. 86a (11)		⑱	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE. PAR. 86a (15)	

19 IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

DA FORM 1 MAY 51 11-238 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

TM 5091-402

Figure 57. DA Form 11-238.



SECOND AND THIRD ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT

RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE MULTIPLEXER GROUP AN/TCA-1

EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; Ⓧ Defect corrected.
NOTE: Strike out items not applicable.

NO.	ITEM	CONDITION	NO.	ITEM	CONDITION
①	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT (*receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories*). PAR. 86a (1)		⑲	ELECTRON TUBES - INSPECT FOR LOOSE ENVELOPES, CAP CONNECTORS, CRACKED SOCKETS: INSUFFICIENT SOCKET SPRING TENSION; CLEAN DUST AND DIRT CAREFULLY; CHECK EMISSION OF RECEIVER TYPE TUBES. PAR. 86b (1)	
②	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. PAR. 86a (2)		20	INSPECT FILM CUT-OUTS FOR LOOSE PARTS, DIRT, MISALIGNMENT AND CORROSION.	
③	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS. PAR. 86a (3)		㉑	INSPECT FIXED CAPACITORS FOR LEAKS, BULGES, AND DISCOLORATION. PAR. 86b (2)	
④	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS. PAR. 86a (4)		㉒	INSPECT RELAY AND CIRCUIT BREAKER ASSEMBLIES FOR LOOSE MOUNTINGS; BURNED, PITTED, CORRODED CONTACTS; MISALIGNMENT OF CONTACTS AND SPRINGS; INSUFFICIENT SPRING TENSION; BINDING OF PLUNGERS AND HINGE PARTS. PAR. 86b (3)	
⑤	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION. PAR. 86a (5)		23	INSPECT VARIABLE CAPACITORS FOR DIRT, MOISTURE, MISALIGNMENT OF PLATES, AND LOOSE MOUNTINGS.	
⑥	CHECK FOR NORMAL OPERATION. PAR. 86a (6)		㉔	INSPECT RESISTORS, BUSHINGS, AND INSULATORS, FOR CRACKS, CHIPPING, BLISTERING, DISCOLORATION AND MOISTURE. PAR. 86b (4)	
⑦	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS. PAR. 86a (7)		㉕	INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR CORROSION, DIRT AND LOOSE CONTACTS. PAR. 86b (5)	
⑧	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 86a (8)		㉖	CLEAN AND TIGHTEN SWITCHES, TERMINAL BLOCKS, BLOWERS, RELAY CASES, AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE. PAR. 86b (6)	
⑨	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 86a (9)		㉗	INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS AND BREAKS. PAR. 86b (7)	
10	INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.		28	CHECK SETTINGS OF ADJUSTABLE RELAYS.	
⑪	INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING. PAR. 86a (10)		29	LUBRICATE EQUIPMENT IN ACCORDANCE WITH APPLICABLE DEPARTMENT OF THE ARMY LUBRICATION ORDER.	
⑫	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES. PAR. 86a (11)		30	INSPECT GENERATORS, AMPLIDYNES, DYNAMOTORS, FOR BRUSH WEAR, SPRING TENSION, ARCING, AND FITTING OF COMMUTATOR.	
13	INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.		㉛	CLEAN AND TIGHTEN CONNECTIONS AND MOUNTINGS FOR TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS. PAR. 86b (8)	
⑭	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES. PAR. 86a (12)		㉜	INSPECT TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS FOR OVERHEATING AND OIL-LEAKAGE. PAR. 86b (9)	
⑮	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR. 86a (13)		33	BEFORE SHIPPING OR STORING - REMOVE BATTERIES.	
⑯	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING. PAR. 86a (14)		㉞	INSPECT CATHODE RAY TUBES FOR BURNT SCREEN SPOTS. PAR. 86b (10)	
17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.		35	INSPECT BATTERIES FOR SHORTS AND DEAD CELLS.	
⑱	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE. PAR. 86a (15)		36	INSPECT FOR LEAKING WATERPROOF GASKETS, WORN OR LOOSE PARTS.	
			㊲	MOISTURE AND FUNGIPROOF. PAR. 86b (11)	
38	IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.				

DA FORM 1 MAY 51 11-239 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE. c0—10—84382-1

TM 5091-403

Figure 58. DA Form 11-239.

(8) Inspect the cases and exposed metal surfaces for rust, corrosion, and moisture.

(9) Inspect all cords, cables, wires, and shock mounts for cuts, breaks, fraying, deterioration, kinks, and strain.

(10) Inspect all canvas items, leather, and cabling for mildew, tears, and fraying.

(11) Inspect for looseness of accessible items: switches, knobs, jacks, connectors, electrical transformers, voltage regulator powerstat, relays, blower motors, capacitors, 20-cycle generator, and pilot light assemblies.

(12) Clean the name plates, meter windows, jewel assemblies, and the video restorer and filament supply air filters. Clean the filament supply filter as follows.

(*a*) Remove the filament supply filter cover by unscrewing the four filament panel mounting screws (fig. 34) mounting it to the electrical equipment rack (fig. 6).

(*b*) Remove the filter from its mounting cover and clean with solvent (SD).

(*c*) Replace the air filter in its mounting cover with the arrow next to the words AIR FLOW pointing towards the rack.

(*d*) Remount the air filter mounting cover to the rack with the four filament panel mounting screws.

Note. This air filter must be cleaned every week. Failure to do this will result in improper operation of the multiplexer group.

(13) Inspect the audio test set and power supply meters for damaged glass and cases.

(14) Inspect all shelters and covers for rips, tears, and adequacy of weatherproofing.

(15) Check the switch box cover for cracks, leaks, dirt, and grease.

Caution: Disconnect all power from the multiplexer group before performing the following operations. Upon completion, reconnect power and check for satisfactory operation of the multiplexer group.

b. Interior Items.

(1) Inspect electron tubes for loose envelopes, cap connections, cracked sockets, and insufficient socket spring tension. Clean dirt and dust carefully.

(2) Inspect fixed capacitors for leaks, bulges, and discoloration.

(3) Inspect relays and circuit breakers for loose mountings; burned, pitted, and corroded contacts; misalignment of contacts, insufficient spring tension; binding of plungers and hinge parts.

(4) Inspect resistors, bushings, and insulators, for cracks, chipping, blistering, discoloration, and moisture.

(5) Inspect terminals of large fixed capacitors and resistors for corrosion, dirt, and loose contacts.

(6) Clean and tighten switches, terminal blocks, blowers, relay cases, and interiors of chassis and cabinets not readily accessible.

(7) Inspect terminal blocks for loose connections, cracks, and breaks.

(8) Clean and tighten connections and mountings for transformers, chokes, and potentiometers.

(9) Inspect transformers, chokes, and potentiometers for overheating and oil leakage.

(10) Inspect the oscilloscope cathode-ray tube (crt) for burned screen spots.

(11) Inspect all components for adequacy of moistureproofing and fungiproofing.

Section III. LUBRICATION AND WEATHERPROOFING

87. Lubrication

Multiplexer Group AN/TCA–1 requires no lubrication.

88. Weatherproofing Procedures and Precautions

a. General. Signal Corps equipment, when operated under severe climatic conditions such as prevail in tropical, arctic, and desert regions, requires special treatment and maintenance. Fungus growth, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials.

b. Tropical Maintenance. A special moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection. This treatment is explained in TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment, and TB SIG 72, Tropical Maintenance of Ground Signal Equipment. Use this treatment only when parts are replaced or repaired.

c. Arctic Maintenance. Special precautions necessary to prevent poor performance or total operational failure of equipment in extremely low temperatures are explained in TB SIG 66, Winter Maintenance of Signal Corps Equipment, and TB SIG 219, Operation of Signal Equipment at Low Temperatures.

d. Desert Maintenance. Special precautions necessary to prevent equipment failure in areas subject to extremely high temperatures, low humidity, and excessive sand and dust are explained in TB SIG 75, Desert Maintenance of Ground Signal Equipment.

89. Rustproofing and Painting

a. When the finish on the case has been badly scarred or damaged, rust and corrosion can be prevented by touching up bared surfaces. Use #000 sandpaper to clean the surface down to the bare metal; obtain a bright smooth finish.

Caution: Do not use steel wool. Minute particles frequently enter the case and cause harmful internal shorting or grounding of circuits.

b. When a touch-up job is necessary, apply paint with a small brush. Remove rust from the case by cleaning corroded metal with solvent (SD). In severe cases, it may be necessary to use solvent (SD) to soften the rust and to use sandpaper to complete the preparation for painting. Paint used will be authorized and consistent with existing regulations.

Section IV. TROUBLE SHOOTING AT ORGANIZATIONAL MAINTENANCE LEVEL

90. Extent of Instructions

a. The trouble shooting and repair work that can be performed at the organizational maintenance level (operators and repairmen) is necessarily limited in scope by the tools, test equipment, and replaceable parts issued, and by the existing tactical situation. Accordingly, trouble shooting is based on the performance of the equipment, visual inspection, and the use of the senses in determining such troubles as burned-out tubes, broken leads, and interpretation of the wave forms at the test points. Most multiplexer trouble shooting can be done by comparison of wave forms in conjunction with the oscilloscope probe.

b. The following paragraphs will help to determine which component, such as the video restorer or modem, is at fault and to localize the fault in that component to the defective stage or item, such as a tube or fuse. For convenience all waveshapes are shown for a 23-channel pulse train, unless otherwise noted.

c. The first step in such servicing is to localize the fault to the restorer group rather than some other part of the radio-relay system in which it may be operating. This can be done by inspecting the input and output waveshapes. Set up the oscilloscope as described in paragraph 55 and insert the oscilloscope probe into

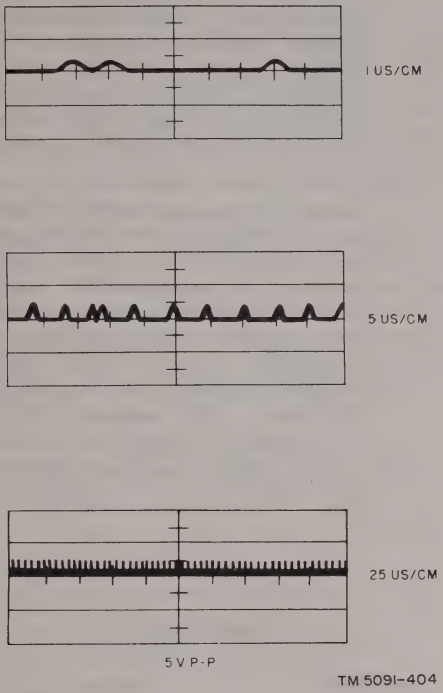


Figure 59. Input wave form, at E1, INPUT FROM EASTFACING REC.

the video restorer OUTPUT TO EASTFACING XMTR test point or OUTPUT TO WESTFACING XMTR test point. A wave form similar to that shown in figure 60 should be displayed on the crt screen. Since the unit has two identical parts, one eastgoing and one westgoing, all procedures will be referred to as eastgoing, with the understanding that such procedures should also be applied to the westgoing section in the same way. If the output is not correct, check the wave form at the INPUT FROM EASTFACING REC test point. The wave form should be as shown in figure 59.

d. The absence of one of these signals indicates that either the equipment or the system is faulty. If the input is correct but the output is not, the fault probably lies in the equipment. In that case, proceed as outlined in the following paragraphs. Whenever possible, perform all the indicated checks in the order given.

91. Visual Inspection

a. Failure to operate properly will usually be caused by one or more of the faults listed below. Other causes for failure are described in chapter 7.

(1) Burned-out fuse.

(2) Defective tubes.

(3) Faulty setting of switches or controls.

b. When failure is encountered and the cause is not immediately apparent, check the above three faults before starting a detailed system examination. If possible, obtain information from the operator of the equipment regarding performance at the time the trouble occurred.

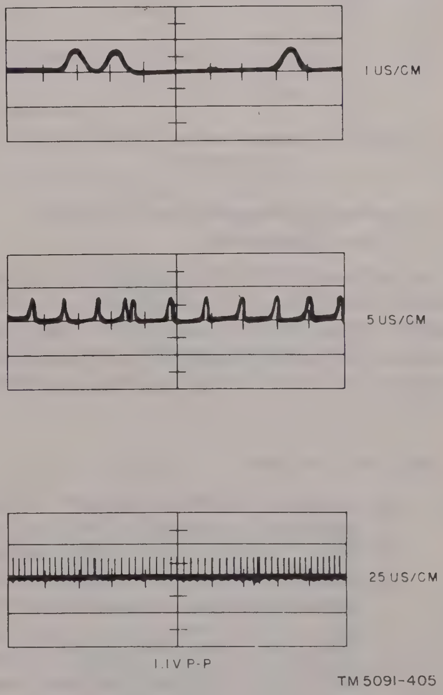


Figure 60. Output wave form, at E2, OUTPUT TO WESTFACING XMTR.

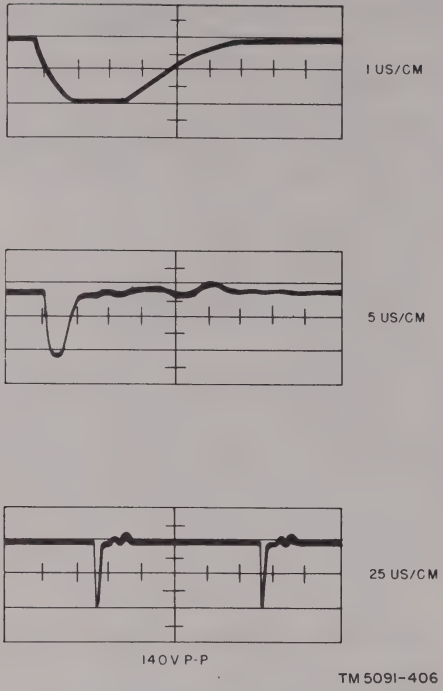


Figure 61. Wave form at DEMTPX GATE test point E5.

92. Service Sectionalization of Trouble to a Component

When servicing the equipment, the first procedure is to localize the difficulty to a component. The difficulty may be in the video restorer, modems, mounting rack, power supply, test equipment, or voltage regulator switch box.

a. Video Restorer.

(1) *General.* The video restorer may be separated functionally into two sections. The first is the *series* section; that is, that part through which the signal progresses. In general, this consists of the reshaping circuit (V1 through V5, V6 through V9, and V10) and the blanking and insert circuit (V11 through V13). The second consists of the *bridged* section, which consists of a marker-separator gate-shaping circuit and an alarm circuit. Failure of either of these sections (series or bridged) will be immediately apparent since the alarm will operate. Failure of each of these sections will be considered separately.

(2) *Series section.* Failure of the series section will be apparent since the signal will bypass the circuits. In normal operation, the P.T. OUT AMPL switch (S2) is in the LOW position and the output pulse train amplitude is set equal to the input pulse train amplitude observed at the INPUT FROM EASTFACING (or WEST-FACING) REC test jack (J2). In the event of a failure, the amplitude of the output pulse train observed at the OUTPUT TO EASTFACING

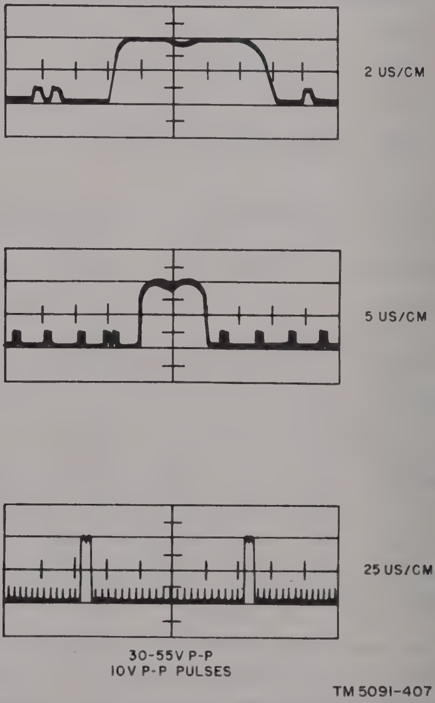
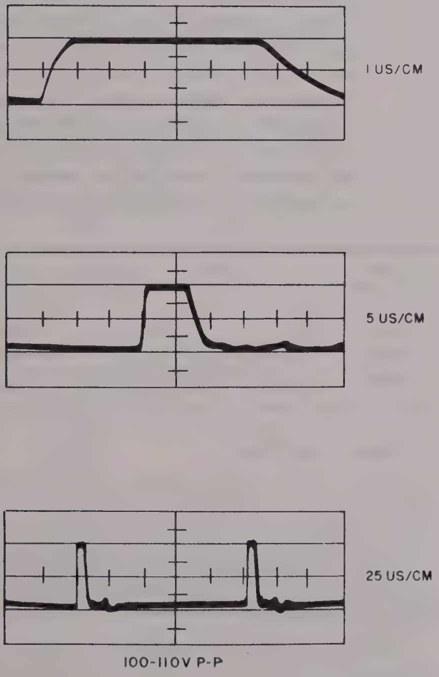


Figure 62. Wave form at BLANKING GATE test point E4 (channels 1 and 2 in D&I).

(or WESTFACING) XMTR test jack (J4) should not change. This is caused by the following reason. When P.T. OUT AMPL switch S2 is in the LOW position, a 12-db pad attenuates the signal and the output amplitude is set to be one-half the input video level. When P.T. OUT AMPL switch S2 is in the HIGH position, a 6-db pad attenuates the output pulse train instead of the 12-db pad. When the video restorer is in the *alarmed* condition, a 6-db pad also attenuates the bypassed input signal. Consequently, in the event of failure, the amplitude of the output pulse train should not change.

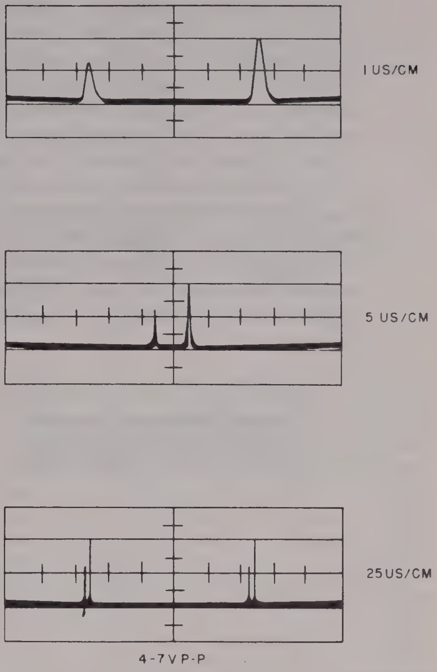
Note. Stages V1 through V5 are turned off in normal 23-channel operation.

(3) *Bridged circuit.* If the alarm sounds and the fault is not in the series circuit, it must, therefore, be in the bridged circuit. Always observe the wave forms above before proceeding. In addition to the alarm sounding, it may become impossible to drop and insert signals. If the trouble appears to be in the bridged circuits, observe the following wave forms.



TM 5091-408

Figure 63. Wave form at MTPX GATE test point E6.



TM 5091-409

Figure 64. Wave form at MODEM CHAN PULSES test point E3.

(*a*) DEMTPX GATE, E5 (fig. 61).

(*b*) BLANKING GATE, E4 (fig. 62).

(*c*) MTPX GATE, E6 (fig. 63).

(*d*) MODEM CHAN PULSES, E3 (fig. 64).

(4) *Stage-by-stage plate wave forms.* If all the wave forms mentioned in subparagraph (3) above are present and correct, no further inspection is necessary. If not, check the stage

plate wave forms of the appropriate section as listed in the following chart. Refer to figure 97 for tube locations. Check tubes V6 to V13 for trouble in the series section, and tubes V19 to V27 for trouble in the shunt section. The remainder of the tubes are the alarm and miscellaneous circuits. Absence or distortion of any one of the wave forms indicates that the stage is faulty. When such a stage is located, change the tube of that stage. If a tube change does not correct the situation, the equipment must be serviced. For servicing refer to chapter 7.

Tube No.	Pin No.	Fig. ref
V1	8	65
V2	5	66
V3	7	67
V4	5	68
V5	6	69
V6	8	70
V7	5	71
V8	7	72
V9	5	73
V10	6	74
V11	6	75
V12	1	76
V13	3	62
V15A	1	78
V16	6	79
V19	5	80
V20	8	81
V21	8	82
V22	8	83
V23	5	84
V24	5	85
V25	8	61
V26	5	86
V27	5	63

b. Modem Modulator.

(1) *Test points* (fig. 87). Check the PPM test point on each modem against the wave form shown in figure 88.

(2) *Stage plate wave forms.* If the PPM test point wave form is satisfactory, the modem modulator is operating properly. If it is not, check the modem stages plate wave forms as in the chart below. (Refer to figure 98 for the location of all tubes.) Replace any tubes of the defective stages. If the trouble does not disappear, the unit must be serviced. Refer to chapter 7.

Tube No.	Pin No.	Fig. ref
V1A	1	89
V1B	6	90
V2	1	91

c. Modem Demodulator.

(1) *Test point* (fig. 87). Check the wave form at the modem PWM test point. The wave form should be similar to that shown in figure 92.

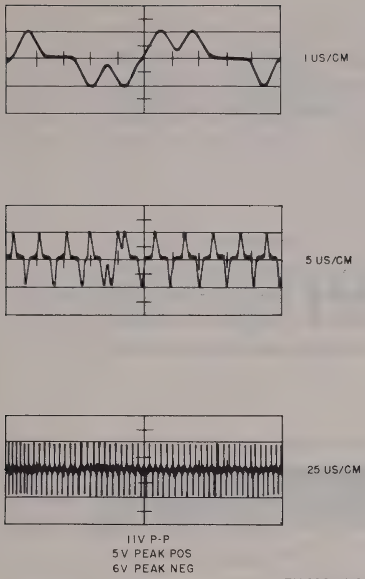
(2) *Stage-by-stage plate wave forms.* If the PWM test point wave form is present and correct, no further inspection is necessary. If it is not, check the modem stages plate wave forms as shown in the chart below. Refer to figure 98 for the location of all tubes. Absence or distortion of any one of the wave forms in the chart indicates a faulty stage. When such a stage is located, change the tube of that stage. If changing the tube does not correct the situation, service the equipment as described in chapter 7.

Tube No.	Pin No.	Fig. ref
V3B	6	92
V3A	1	93
V4A	1	94
V4B	6	95

93. Power Supplies

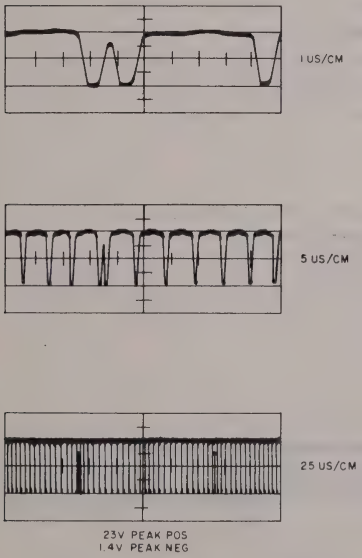
a. B+ Power Supply (Power Supply PP–691/G). There are no tubes in the B+ power supply. If the input voltage is normal, lack of output voltage indicates a need for servicing. Servicing this unit should be done by field maintenance personnel only.

b. Filament Supply (Multiplexer Subassembly MX–1442/TC). There are no tubes in the filament supply. Servicing instructions are described in chapter 7.



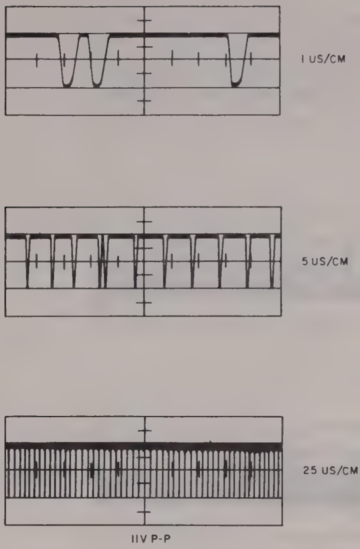
TM 5091-410

Figure 65. Wave form at pin 8 (plate) of V1.



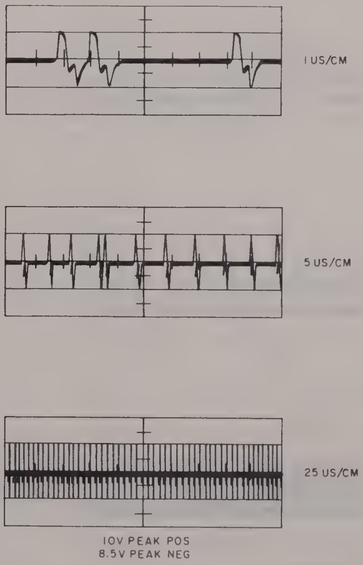
TM 5091-411

Figure 66. Wave form at pin 5 (plate) of V2.



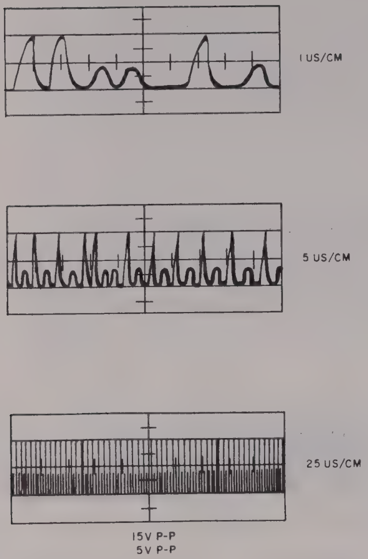
TM 5091-412

Figure 67. Wave form at pin 7 (plate) of V3.



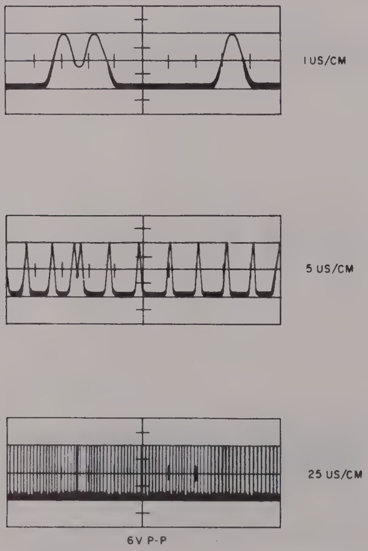
TM 5091-413

Figure 68. Wave form at pin 5 (plate) of V4.



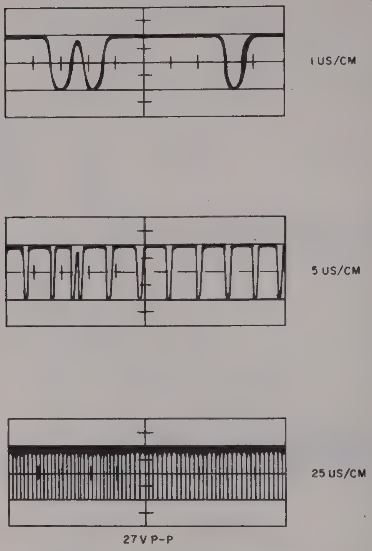
TM 5091-414

Figure 69. Wave form at pin 6 (plate) of V5.



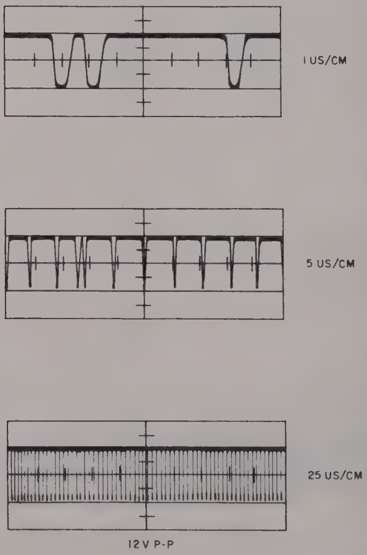
TM 5091-415

Figure 70. Wave form at pin 8 (plate) of V6.



TM 5091-416

Figure 71. Wave form at pin 5 (plate) of V7.



TM 5091-417

Figure 72. Wave form at pin 7 (plate) of V8.

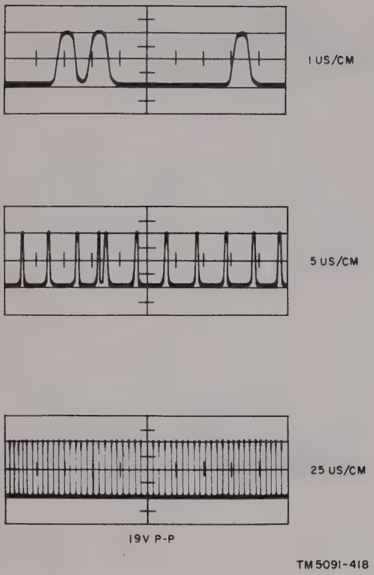


Figure 73. Wave form at pin 5 (plate) of V9.

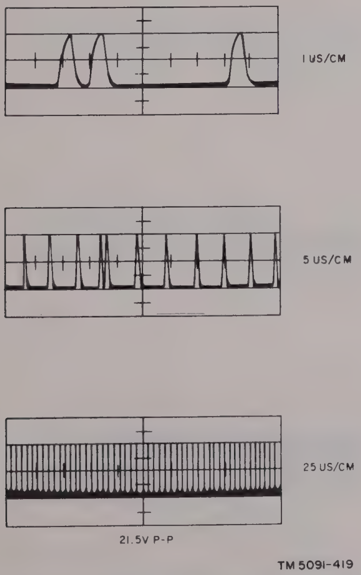


Figure 74. Wave form at pin 6 (plate) of V10.

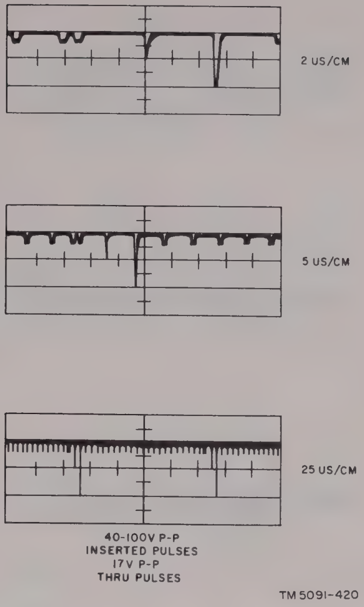


Figure 75. Wave form at pin 6 (plate) of V11.

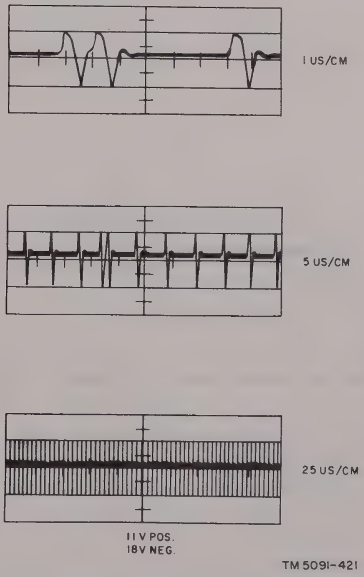
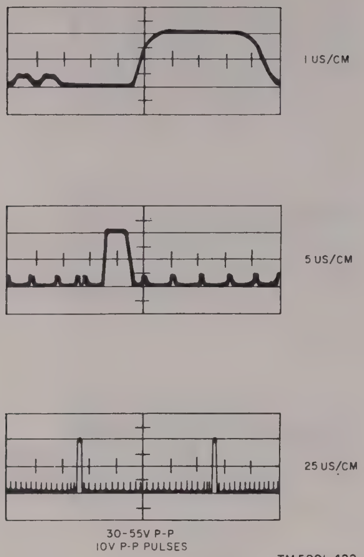
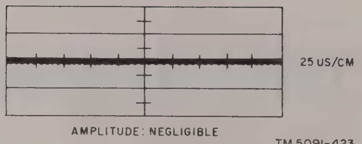


Figure 76. Wave form at pin 1 (plate) of V12.



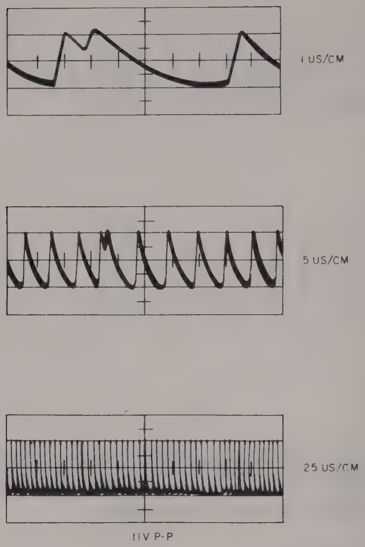
TM 5091-422

Figure 77. Wave form at pin 3 (cathode) of V13 (channel 1 in D&I).



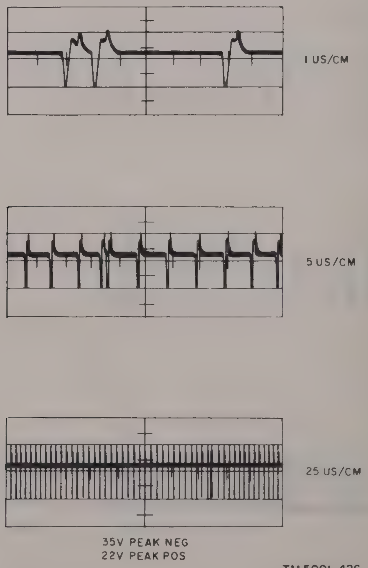
TM 5091-423

Figure 78. Wave form at pin 1 (plate) of V15A.



TM 5091-425

Figure 79. Wave form at pin 6 (plate) of V16.



TM 5091-426

Figure 80. Wave form at pin 5 (plate) of V19.

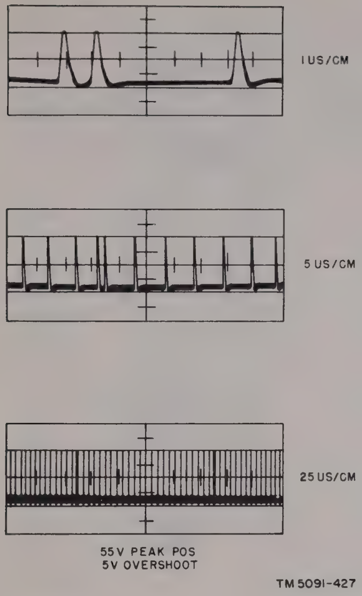


Figure 81. Wave form at pin 8 (plate) of V20.

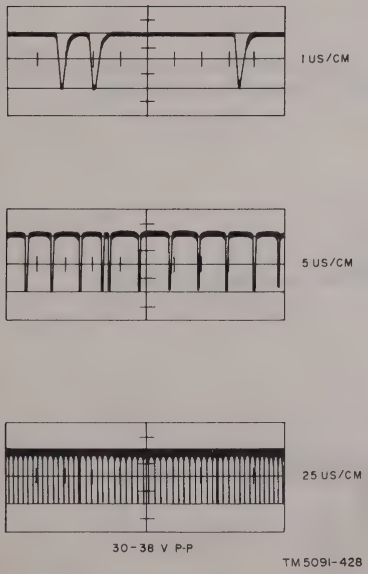


Figure 82. Wave form at pin 8 (plate) of V21.

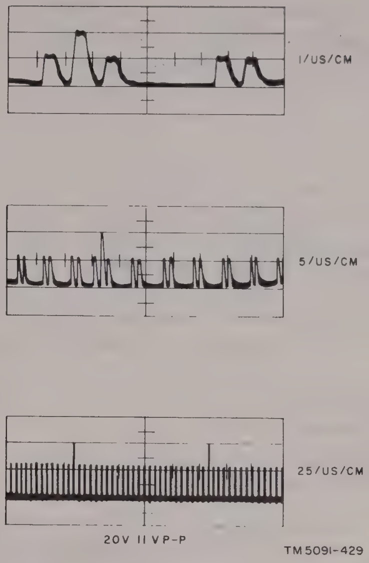


Figure 83. Wave form at pin 8 (plate) of V22.

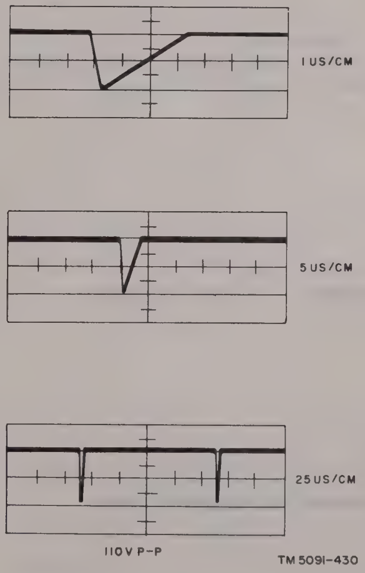
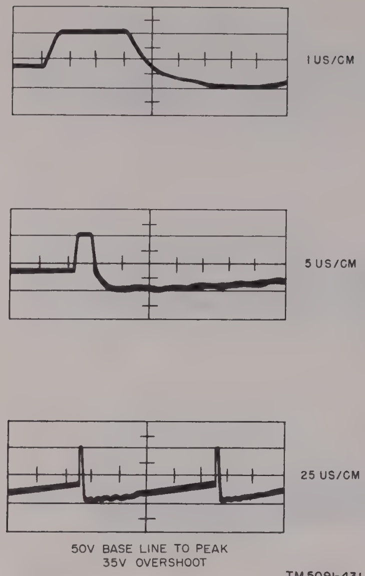
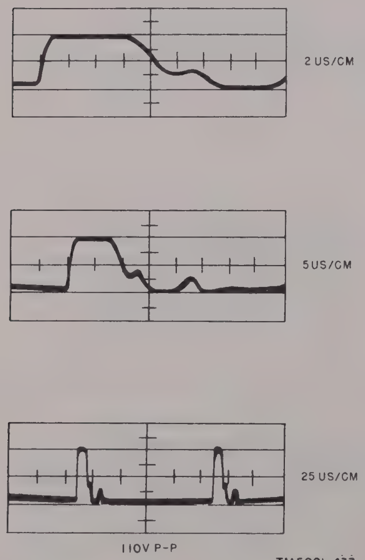


Figure 84. Wave form at pin 5 (plate) of V23.



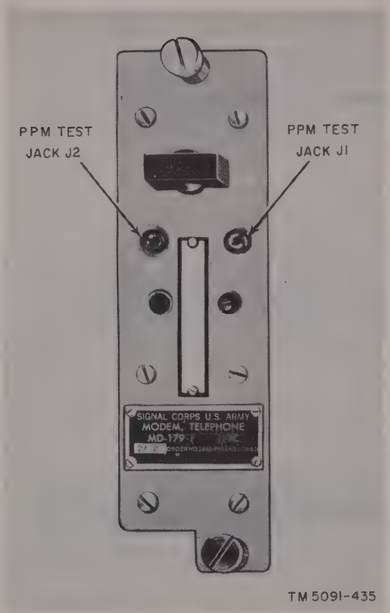
TM 5091-431

Figure 85. Wave form at pin 5 (plate) of V24.



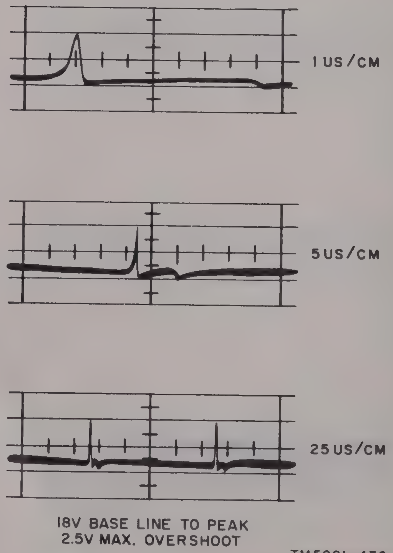
TM 5091-433

Figure 86. Wave form at pin 5 (plate) of V26.


PPM TEST
JACK J2
PPM TEST
JACK J1
SIGNAL CORPS U.S. ARMY
MODEM, TELEPHONE
MD-179

TM 5091-435

Figure 87. Modem test points.



TM 5091-436

Figure 88. Wave form at modem PPM test point.

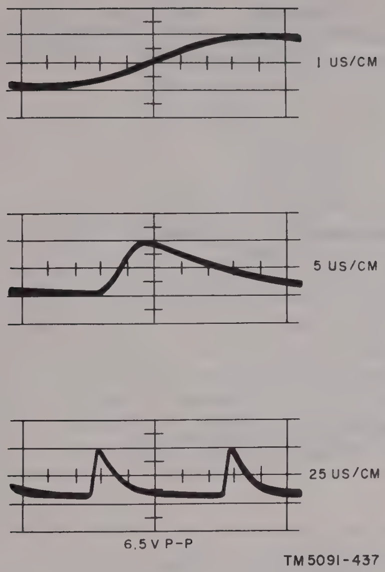


Figure 89. Wave form at pin 1 (plate) of V1A (modem).

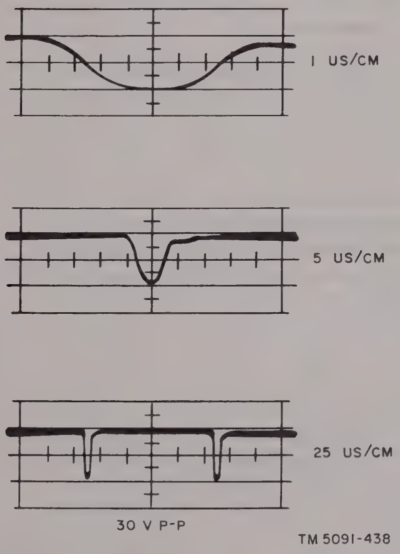


Figure 90. Wave form at pin 6 (plate) of V1B (modem).

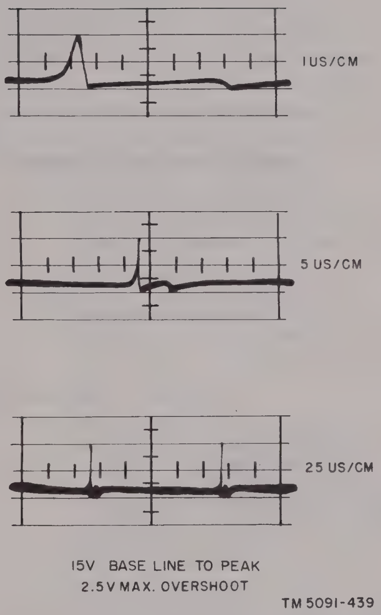
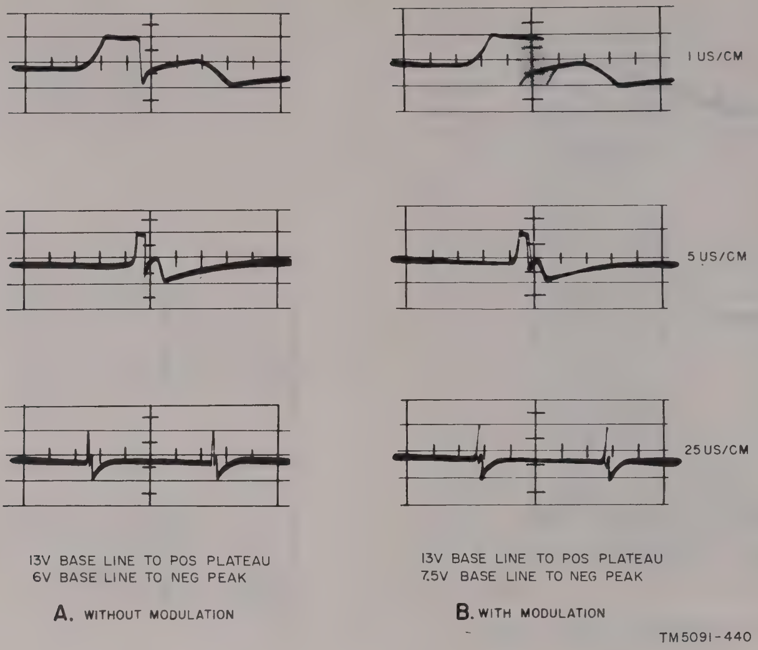


Figure 91. Wave form at pin 1 (plate) of V2 (modem).



A. WITHOUT MODULATION

B. WITH MODULATION

Figure 92. Wave form at modem PWM test point J2 (modem).

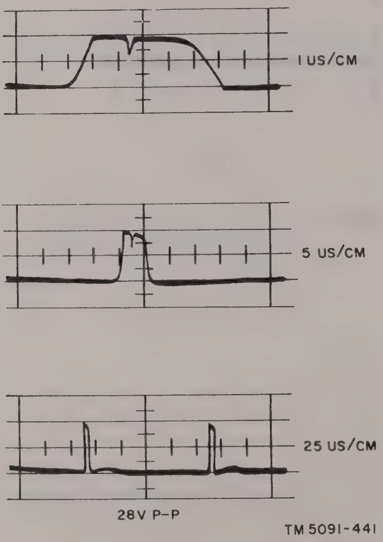


Figure 93. Wave form at pin 1 (plate) of V3A (modem).

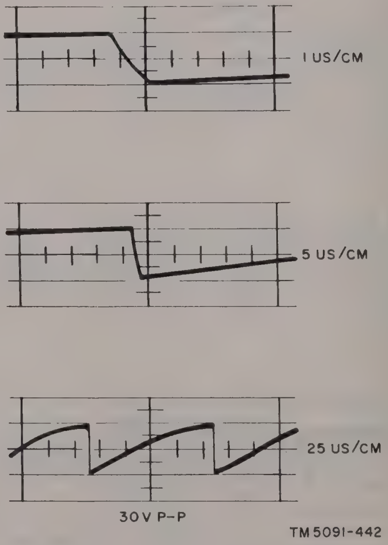


Figure 94. Wave form at pin 1 (plate) of V4A (modem).

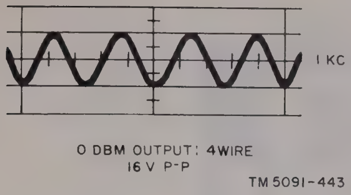


Figure 95. Wave form at pin 6 (plate) of V4B (modem).

c. Voltage Regulator CN–236/G. If the input voltage is normal, lack of output voltage or fluctuation of the output voltage indicates a need for servicing. Check tubes V1 and V2, and note that the fluctuation of the output voltage may also be caused by an improper setting of the SENSITIVITY control (fig. 54). If the trouble cannot be corrected, refer to chapter 7.

94. Test Equipment

a. Oscilloscope. Trouble in the oscilloscope may be localized by noting the following:

(1) Oscilloscope trouble is completely independent of the remainder of the multiplexer group and usually cannot affect the operation of the rest of the set.

(2) Failure of the power system will be apparent by the lamp indicator not lighting in either the oscilloscope or the test set. This is usually caused by a blown fuse. No harm is done if the defective fuse is replaced immediately and the power switch turned on again. However, if the fuse blows again, the trouble can be serious and the fuse should not again be replaced without first locating and correcting the trouble. This precaution also applies to the test set. Voltage at test points +450V and +225V (fig. 96) at the rear of the chassis should be checked with a vtvm. If these voltages are present and correct, it is an indication that all low voltages are correct.

(3) If the voltages are correct, check the operational controls as follows:

(*a*) Set the front panel controls (fig. 50) as indicated below:

Control	Position
SYNC SELECTOR	+INT
COARSE	5000
FINE	10
INTENSITY	Clockwise
HOR POSITION	Middle of range
VERT POSITION	Middle of range
TIMING PIP PHASE	Off
CAL VOLTAGE	5
VERT ATTEN	CAL
VERT GAIN	Clockwise
TRIGGER	Counterclockwise
STAB	Counterclockwise

Note. The controls should turn smoothly, and the image on the screen should move slowly without jumping.

(*b*) Advance the STAB control clockwise until a sweep appears; then turn it counterclockwise until the sweep just disappears.

(*c*) Advance the TRIGGER control clockwise until a stable image of a clipped sine wave (fig. 209) appears.

(*d*) Vary the HOR POSITION and VERT POSITION controls to see if the oscilloscope presentation moves in a horizontal and vertical direction. Return the trace to the center of the screen.

(*e*) Vary the INTENSITY control to see if it provides normal intensity variations. The picture should be blanked out with the control fully counterclockwise and become brighter as it is advanced clockwise.

(*f*) Vary the FOCUS, ASTIG, and INTENSITY controls until a sharp focused trace is obtained. This can be considered a test for the FOCUS and ASTIG controls.

(*g*) Vary the VERT GAIN control to see if the vertical size of the presentation can be increased and decreased.

Note. If the operation of these controls is not correct, refer to chapter 7.

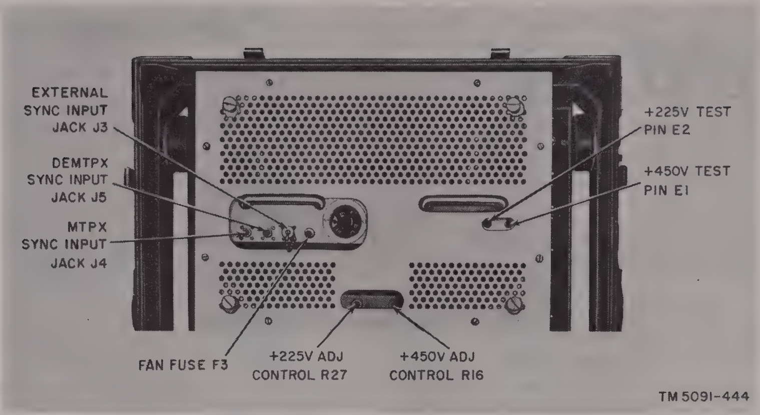


Figure 96. Oscilloscope test points.

b. Audio Test Set TS–762/TC.

(1) If the audio test set is totally inoperative, check tube V8.

(2) Adjust the SEND-CALIBRATE circuit (par. 55 *c*(1)). If this adjustment cannot be done, check tubes V1 through V4 and lamp I 1.

(3) If subparagraphs (1) and (2) above indicate correct operation, but the REC-CALIBRATE circuit cannot be adjusted (par. 55 *c* (2)), check tubes V6 and V7.

(4) If the incoming tone can be measured, but the REC-CALIBRATE circuit cannot be adjusted, repeat the procedures outlined in subparagraph (2) above.

(5) If the meter does not read, check tube V5.

c. Control Monitor C–1151/TC.

(1) *Switching functions.* Check the switching functions as follows:

(*a*) Turn on the test set and set the SEND-DBM control at a –4-dbm output for four-wire, or at –3 dbm for two-wire connection.

(*b*) Place the control monitor panel switch in the SEND position.

(*c*) Turn each modem switch to the SR position, one at a time. Each respective channel pulse should be modulated +.5 microsecond.

(*d*) Place the modem switch in the SL position. The channel pulse should not be modulated, and a level of –4 dbm should be present on the REC line terminals (when terminated by 600 ohms).

(*e*) Place the control monitor switch in the REC position. Now have the other terminal modulate each channel, one at a time. Turn the modem switch of each respective channel, in the terminal being tested, to the RR position and adjust the OUTPUT AUDIO GAIN control on the modem until the test set reads 0 dbm output for four-wire, or –3 dbm for two-wire connection.

(*f*) Connect a level of –4 dbm on the line to each 4W SEND terminals with the modem switch in the RL position. The test set should read –4 dbm and the channel pulse should not be modulated.

(2) *Telephone circuit.* Check the telephone circuit as follows:

(*a*) Place the control monitor switch of both terminals in the NORMAL position.

(*b*) Have the operators at the east and west terminals place channel 1 of both terminals in two-wire operation.

(*c*) Press the RING switch on the control monitor panel of each terminal. The RING bell and the bell on the other terminal should ring.

(*d*) It should be possible to talk between the two handsets over channel 1.

(*e*) Place the control monitor panel switch in TEL SET position for each terminal.

(*f*) Have the operators at both terminals place channel 2 of both terminals in two-wire operation. It should be possible to talk between the handsets over channel 2 by placing channel 2 of each unit in either RR or SR position.

(*g*) Have the operators of the terminals return channels 1 and 2 in both terminals to four-wire operation and place both control monitor switches in the NORMAL position.

95. Miscellaneous Circuits

a. Drop and Insert. Check that the 16 D&I switches (fig. 42) are inserted firmly and are correctly orientated.

b. Party Line-Private. Check that the PARTY LINE-PRIV switches (fig. 42) are inserted firmly and are correctly orientated.

c. Filament Supply. Check the output of the filament transformer. If in doubt, remove the load from the secondary of the transformer, and check the no-load output voltage. If there is 115 volts ac across the primary and an incorrect secondary output, replace the transformer.

d. Ringing Circuits. Check ringing as follows. Have the east and west operators ring, and see if a telephone at the multiplexer group rings. Similarly, ring the west or east terminal. If this ringing test is successful on a party-line connection (both incoming and outgoing), no further tests are necessary. If the ringing circuit does not operate on party line, but does on private, then check the remote keying circuit (subpar. *f* below). If the ringing circuit does not operate correctly on either party-line or private connection, check the modems as follows:

(1) Have the terminal operator connect one field Telephone EE–8–B to the 4W SEND terminals of the far terminal. Connect field Telephone EE–8–B to the 4W REC terminals of the local terminal under test.

(2) Have the terminal operator at the distant terminal crank the telephone on the 4W SEND terminals. The telephone on the 4W REC terminals at the local terminal should ring.

(3) Crank the telephone on the 4W SEND terminals at the local terminal. The telephone on the 4W REC terminals at the far terminal should ring.

(4) Alternately, the switchboards at the terminal locations should ring each other, on each channel, in turn.

e. Alarm Circuit. Check the alarm circuit as follows:

(1) Remove the pulse train input cable from the video restorer. The alarm should sound and the ALARM indicator on the multiplexer subassembly panel (fig. 32) should light.

(2) Press the AUDIBLE ALARM DISCONNECT switch on the multiplexer subassembly panel. The alarm should no longer sound, but the indicator light should remain lighted.

(3) Reconnect the pulse train input cable. The alarm indicator light should go out.

f. Remote Keying Circuits.

(1) *Normal operation.* If the terminal has passed the preceding tests, the remote keying units should be working properly in NORMAL operation.

(2) *Remote keying operation.* Have the operators at the distant terminal place the two remote keying units in the remote keying operation. Place

the two remote keying units at the local terminal in remote keying operation. Channels 1 and 2 should be blanked out in both units. There should be an open circuit between E11 and E12 (REMOTE KEYING UNIT OUT) and also between E1 and E2 (REMOTE KEYING UNIT OUT) of the Multiplexer Subassemblies MX–1442/TC of both terminals.

(*a*) Put a short circuit across E13 and E14 (REMOTE KEYING UNIT IN) of the local terminal. This should put channel 1 pulse back in the multiplexer pulse train. There should still be an open circuit across E11 and E12 of the local terminal.

(*b*) Put a short circuit across E3 and E4 (REMOTE KEYING UNIT IN) of the local terminal. This should put channel 2 pulse back in the multiplexer pulse train of the local terminal. There should still be an open circuit across E1 and E2.

(*c*) Have the operator at the distant terminal put a short circuit across E13 and E14. There should now be a short circuit across E11 and E12 on the local terminal being tested.

(*d*) Have the operator of the distant terminal put a short circuit across E3 and E4. There should now be a short circuit across E1 and E2 on the local terminal.

96. Trouble Shooting with Equipment Performance Checklist

a. General. The equipment performance checklist (par. 97) will help the operator to locate trouble in the equipment. The list gives the item to be checked, the condition under which the item is checked, the normal indications of correct operation, and the corrective measures the operator can take. *To use this list, follow the items in numerical sequence.*

b. Action or Condition. For some items, the information given in the *Action or condition* column consists of various switch and control settings under which the item is to be checked. For other items it represents an action that must be taken to check the normal indication given in the *Normal indications* column.

c. Normal Indications. The normal indications listed include the visible and audible signs that the operator should perceive when checking the items. If the indications are not normal, the operator should apply the recommended corrective measure.

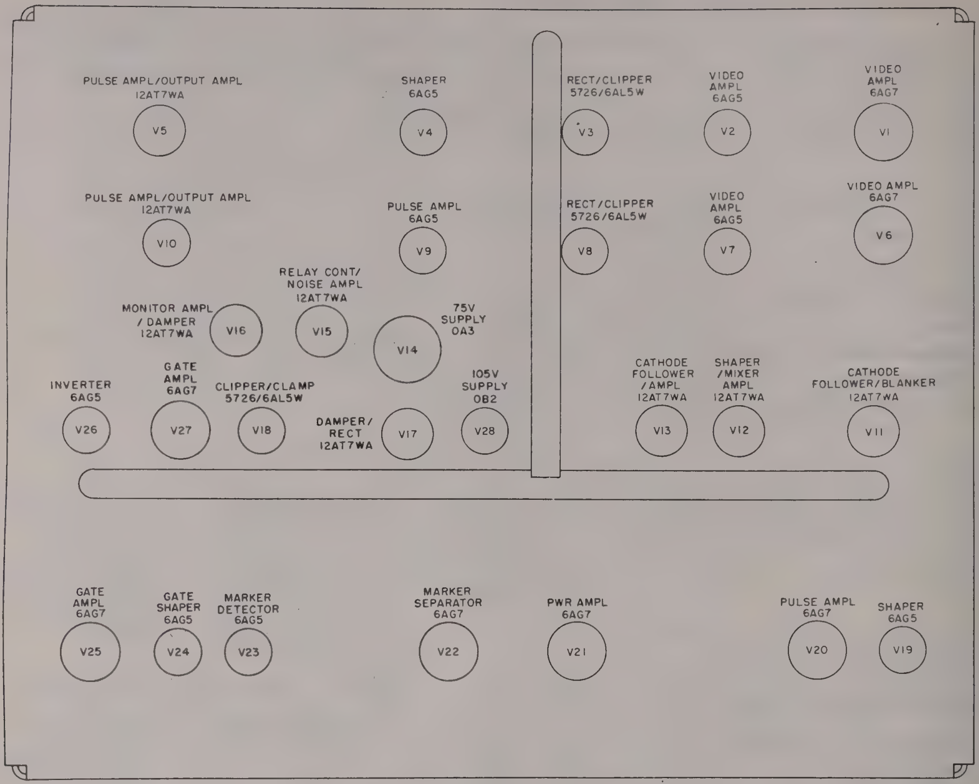
d. Corrective Measures. The corrective measures listed are those the operator can normally make without shutting down the equipment. If the set is completely inoperative, or if the recommended corrective measures do not yield results, trouble shooting at a field maintenance level is required. However, in a tactical situation, where the set is not completely inoperative and the commanding officer indicates that the set be kept in operation, the operator will maintain and operate the set as long as possible.

97. Equipment Performance Checklist

	Item No.	Unit	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1		Cables	Check connections (par. 51).		
	2		Power switches	Set to ON position.	Panel lights on; power present.	Check power source; check fuses.
	3	Modem	2W-4W modem switches	Set in 2W or 4W position (fig. 41).	Reception satisfactory on two- or four-wire.	
	4	Filament supply	Remote keying units	Set in NORMAL or REMOTE KEYING position.		

97. Equipment Performance Checklist (cont)

	Item No.	Unit	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	5	Control monitor	Control monitor switch	Depress NORMAL button.		
	6	Modem	Modem selector switch	Set in OPER position.		
	7	Switch box	Switch box	Set to desired input source.		
START	8	Voltage regulator	Circuit breakers	Throw either 115v or 230v circuit breaker ON to agree with input power source		
	9	Filament supply	Filament supply	Throw power supply filament circuit breaker to FILAMENT position.	FILAMENT ON indicator lamps should light, blower should operate, and meter should read 115 volts +1 per cent.	Check fuses and indicator lamps. For improper voltage reading, adjust voltage regulator (par. 54*b*(3)).
STOP	10	Power supply	Plate supply	Throw power supply plate supply circuit breaker to +250V position.	+250V indicator lamps should light.	Check indicator lamps; check fuses in filament supply and video restorer.
	11	Oscilloscope	Oscilloscope power switch	Set to ON position.	POWER indicator lamp should light.	Check oscilloscope fuses, indicator lamp, and power cord.
	12	Test set	Test set power switch	Set to ON position.	POWER indicator lamp should light.	Check test set fuse and indicator lamp.
	13	Video restorer	Wave forms	Check pulse train output wave form.	Refer to paragraph 92*a*.	Change tubes.
	14	Power supply	+250v power switch	Set in OFF position.	Associated indicator lamps should go off.	
	15	Power supply	Filament supply switch	Set in OFF position.	Filament indicator lamps should go off; blower motor should stop.	


PULSE AMPL/OUTPUT AMPL
12AT7WA
V5
SHAPER
6AG5
V4
RECT/CLIPPER
5726/6AL5W
V3
VIDEO
AMPL
6AG5
V2
VIDEO
AMPL
6AG7
V1
PULSE AMPL/OUTPUT AMPL
12AT7WA
V10
PULSE AMPL
6AG5
V9
RECT/CLIPPER
5726/6AL5W
V8
VIDEO
AMPL
6AG5
V7
VIDEO AMPL
6AG7
V6
RELAY CONT/
NOISE AMPL
12AT7WA
V15
MONITOR AMPL
/ DAMPER
12AT7WA
V16
75V
SUPPLY
OA3
V14
INVERTER
6AG5
V26
GATE
AMPL
6AG7
V27
CLIPPER/CLAMP
5726/6AL5W
V18
DAMPER/
RECT
12AT7WA
V17
105V
SUPPLY
OB2
V28
CATHODE
FOLLOWER
/AMPL
12AT7WA
V13
SHAPER
/MIXER
AMPL
12AT7WA
V12
CATHODE
FOLLOWER/BLANKER
12AT7WA
V11
GATE
AMPL
6AG7
V25
GATE
SHAPER
6AG5
V24
MARKER
DETECTOR
6AG5
V23
MARKER
SEPARATOR
6AG7
V22
PWR AMPL
6AG7
V21
PULSE AMPL
6AG7
V20
SHAPER
6AG5
V19

TM5091-401

Figure 97. Video restorer, tube location diagram.

98. Tube Trouble-shooting Charts

a. General. When replacing tubes, refer to figures 97 through 103 for tube locations. The modem tube location diagram (fig. 98) is the same for all modems.

b. Interchangeable Tubes. A preferred-type electron tube, type 5R4WGA, has been developed as a direct replacement for tube type 5R4WGY. These tubes may be used interchangeably in +225-volt rectifier V7, in the oscilloscope. The older type tube should be used until stocks are exhausted.

c. Tube Trouble-shooting Charts.

Item No.	Unit	Symptoms	Tubes
1	VIDEO RESTORER	No gate at the DEMPTX GATE test point (E5).	V6 through V9, and V19 through V25.
2		All blanking gates missing at the BLANKING GATE test point (with all channels in D&I and NORMAL operation).	V13.
3		No gate at the MTPX GATE test point.	V26 and V27.
4		MTPX GATE wave form improper.	V18 or V28 if gate is greater than 110 volts.

Item No.	Unit	Symptoms	Tubes
5	VIDEO RESTORER	Channel pulse too small at the MODEM CHAN PULSES test point.	V1 and V2 (in modems).
6		No inserted pulse at the OUTPUT TO XMTR test point (in D&I and NORMAL).	V10 and V12.
7		In 45-channel operation, negative pulses at the OUTPUT TO XMTR test point too wide.	V1 through V5.
8		Alarm is actuated.	V10, V11, V12, V15, V16, V17, and V18.
9	MODEM	Cannot modulate a channel.	V1 in that channel.
10		Low modulation sensitivity.	CR1, CR2, and V1.
11		No channel pulse.	V1 and V2.
12		Improper channel pulse.	V1, V3, and CR3.
13		Cannot receive audio over a channel although test scope shows modulated pulse present.	V3 and V4.
14		Insufficient audio gain.	V4.
15		Cannot signal.	V3 and V5.
16		Continuous signaling.	V3 and V5.
17		Improper pwm wave form.	V3, CR4, and CR5.
18		Excessive distortion in individual channel.	CR1, CR2, V1, and V4.
19	VOLTAGE REGULATOR	Lack of regulation; motor does not operate in both directions.	V1 and V2.
20	OSCILLOSCOPE	Screen blank when horizontal control is turned fully clockwise	V32 (crt).
21		Vertical deflection but no horizontal deflection.	V15 through V27, 10 neon coupling tubes, V1 and V2.
22		Horizontal deflection, but no vertical deflection.	V12 through V15, V2, and probe.
23		Cannot focus display.	V1, V2, and probe.
24		Cannot position horizontally.	V1 through V11, V25, V26, 10 neon coupling tubes.
25		Cannot position vertically.	V6 through V11.
26		Cannot stop (synchronize) display.	V16 through V19.
27		Cannot phase display with sweep-phase control despite normal synchronization input from multiplexer.	V16 through V19.
28		No timing pip markers.	V28 through V31.
29		Incorrect spacing between markers.	V28 through V31.
30		Extreme vertical distortion or clipping.	V12 through V15.
31		Oscilloscope repeatedly blows fuse F1.	V1 through V7.
32		Timing pips distorted.	V30 and V31.
33		No blanking of retrace.	V19.
34		Weak or dim pattern.	V1, V2, and V32.
35	AUDIO TEST SET	No 1,000-cycle output.	V10 through V13.
36		Meter M1 does not operate on receive.	V1 through V3.
37		Set completely inoperative.	V8.

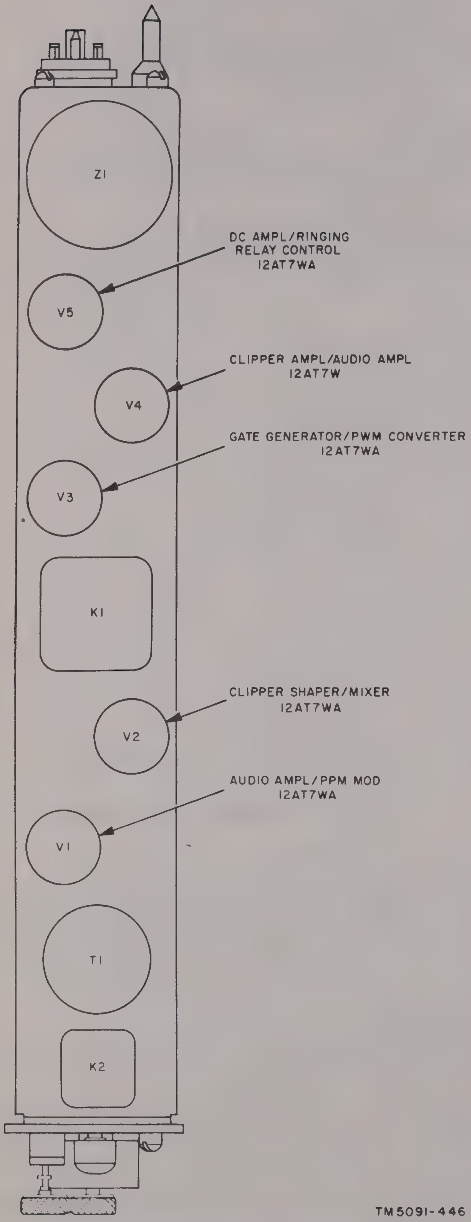

ZI
DC AMPL/RINGING RELAY CONTROL 12AT7WA
V5
CLIPPER AMPL/AUDIO AMPL 12AT7W
V4
GATE GENERATOR/PWM CONVERTER 12AT7WA
V3
KI
CLIPPER SHAPER/MIXER 12AT7WA
V2
AUDIO AMPL/PPM MOD 12AT7WA
VI
TI
K2
TM5091-446

Figure 98. Modem, tube location diagram.

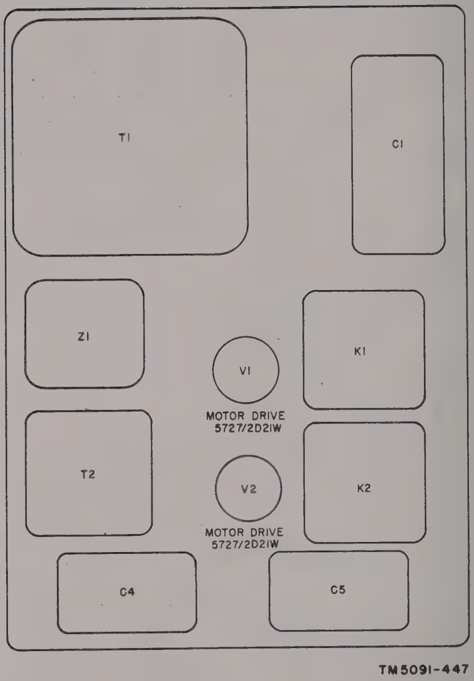

TI
CI
ZI
VI
MOTOR DRIVE 5727/2D21W
KI
T2
V2
MOTOR DRIVE 5727/2D21W
K2
C4
C5
TM5091-447

Figure 99. Voltage regulator, tube location diagram.

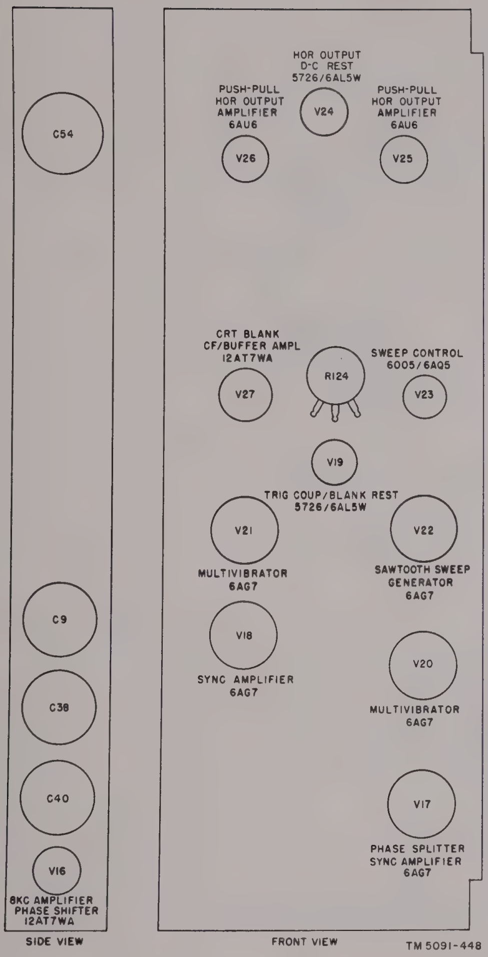

C54
C9
C38
C40
V16
8KC AMPLIFIER
PHASE SHIFTER
12AT7WA
SIDE VIEW
HOR OUTPUT
D-C REST
5726/6AL5W
V24
PUSH-PULL
HOR OUTPUT
AMPLIFIER
6AU6
V26
PUSH-PULL
HOR OUTPUT
AMPLIFIER
6AU6
V25
CRT BLANK
CF/BUFFER AMPL
12AT7WA
V27
R124
SWEEP CONTROL
6005/6AQ5
V23
V19
TRIG COUP/BLANK REST
5726/6AL5W
V21
MULTIVIBRATOR
6AG7
V22
SAWTOOTH SWEEP
GENERATOR
6AG7
V18
SYNC AMPLIFIER
6AG7
V20
MULTIVIBRATOR
6AG7
V17
PHASE SPLITTER
SYNC AMPLIFIER
6AG7
FRONT VIEW
TM 5091-448

Figure 100. Oscilloscope, bottom right section, tube location diagram.

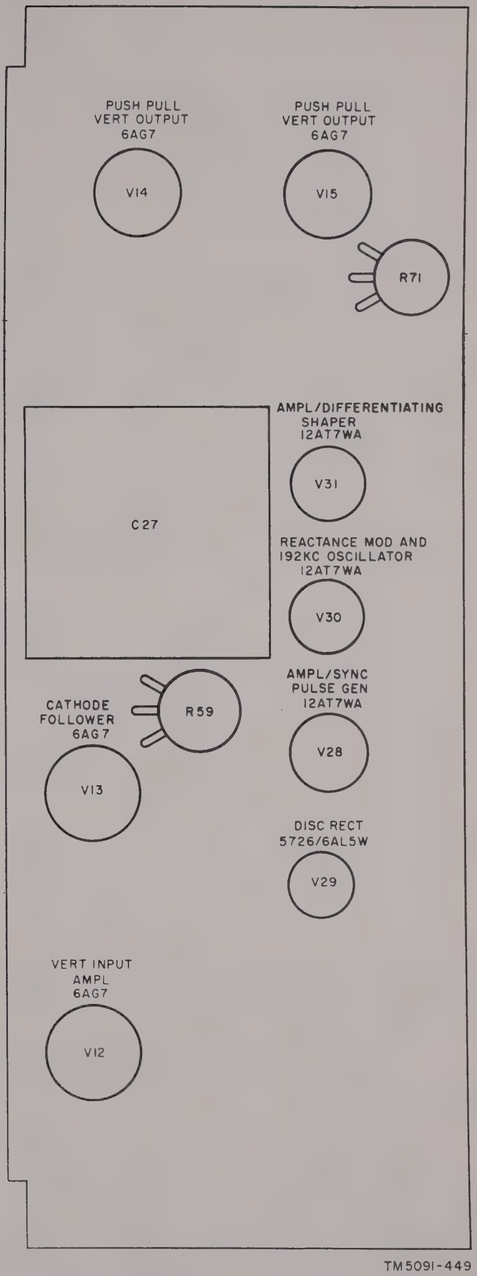

PUSH PULL
VERT OUTPUT
6AG7
V14
PUSH PULL
VERT OUTPUT
6AG7
V15
R71
C27
AMPL/DIFFERENTIATING
SHAPER
12AT7WA
V31
REACTANCE MOD AND
192KC OSCILLATOR
12AT7WA
V30
AMPL/SYNC
PULSE GEN
12AT7WA
V28
CATHODE
FOLLOWER
6AG7
R59
V13
DISC RECT
5726/6AL5W
V29
VERT INPUT
AMPL
6AG7
V12
TM5091-449

Figure 101. Oscilloscope, bottom left section, tube location diagram.

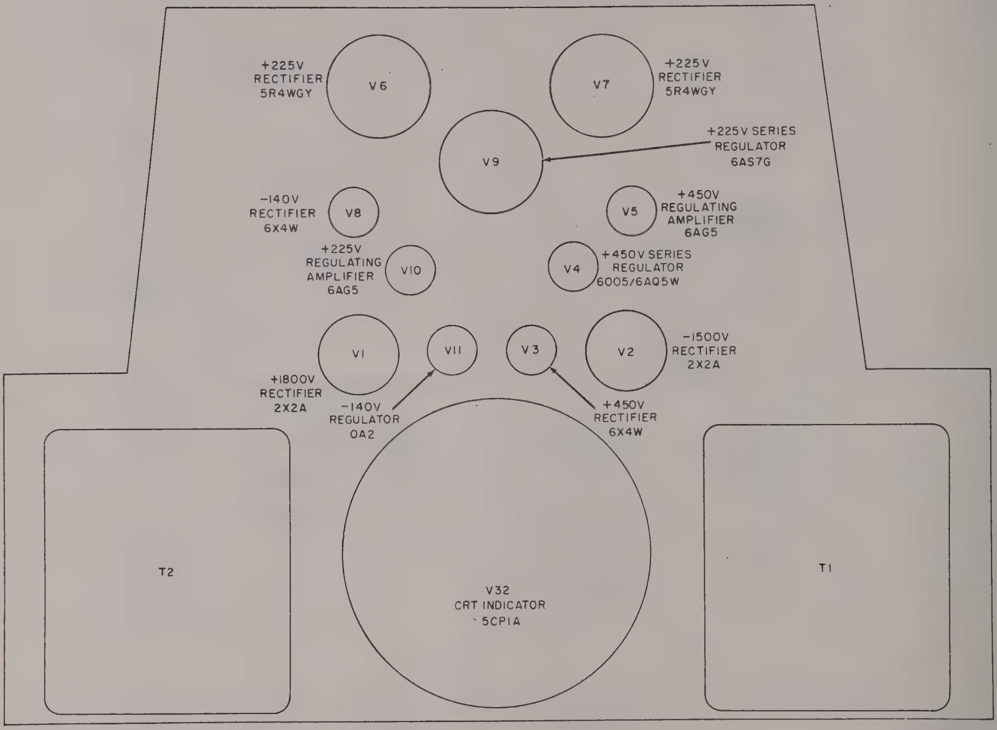
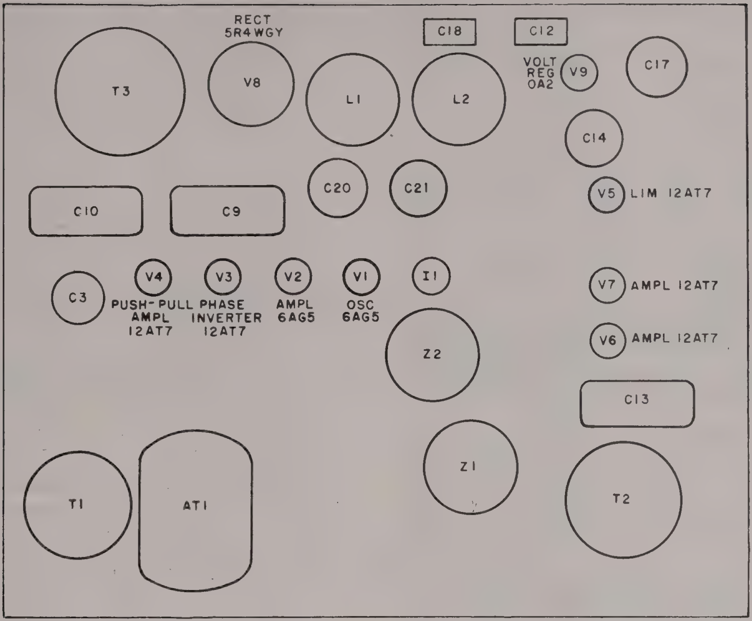

+225V RECTIFIER 5R4WGY
V6
V7
+225V RECTIFIER 5R4WGY
V9
+225V SERIES REGULATOR 6AS7G
-140V RECTIFIER 6X4W
V8
V5
+450V REGULATING AMPLIFIER 6AG5
+225V REGULATING AMPLIFIER 6AG5
V10
V4
+450V SERIES REGULATOR 6005/6AQ5W
V1
V11
V3
V2
-1500V RECTIFIER 2X2A
+1800V RECTIFIER 2X2A
-140V REGULATOR OA2
+450V RECTIFIER 6X4W
T2
V32 CRT INDICATOR 5CP1A
T1
TM 5091-450

Figure 102. Oscilloscope, bottom center section, tube location diagram.


RECT
5R4WGY
V8
T3
L1
L2
C18
C12
VOLT
REG
OA2
V9
C17
C14
C20
C21
V5 LIM 12AT7
C10
C9
C3
V4
V3
V2
V1
I1
PUSH-PULL
AMPL
12AT7
PHASE
INVERTER
12AT7
AMPL
6AG5
OSC
6AG5
V7 AMPL 12AT7
V6 AMPL 12AT7
Z2
C13
Z1
T1
AT1
T2

TM5091-451

Figure 103. Audio test set, tube location diagram.

99. Tube Replacement

The following table identifies all the tubes used throughout the restorer group, by component, reference symbol, tube type, and function. When changing tubes, change them one at a time. Be sure that the correct tube is placed in its proper socket (fig. 97 through 103). Refer to paragraph 98*b* for interchangeable tubes.

Component	Tube symbol	Tube type	Function
VIDEO RESTORER	V1	6AG7	Video amplifier.
	V2	6AG5	Video amplifier.
	V3	5726/6AL5W	Rectifier clipper.
	V4	6AG5	Shaper.
	V5	12AT7WA	Pulse amplifier; output amplifier.
	V6	6AG7	Video amplifier.
	V7	6AG5	Video amplifier.
	V8	5726/6AL5W	Rectifier clipper.
VIDEO RESTORER	V9	6AG5	Pulse amplifier.
	V10	12AT7WA	Pulse amplifier; output amplifier.
	V11	12AT7WA	Cathode follower; blanker.
	V12	12AT7WA	Shaper; mixer amplifier.
	V13	12AT7WA	Cathode follower; amplifier.
	V14	0A3	75-volt supply.
	V15	12AT7WA	Noise amplifier; relay control.
	V16	12AT7WA	Damper; monitor amplifier.
	V17	12AT7WA	Damper, rectifier.
	V18	5726/6AL5W	Clamp; clipper.
	V19	6AG5	Shaper.
	V20	6AG7	Pulse amplifier.

Component	Tube symbol	Tube type	Function
VIDEO RESTORER	V21	6AG7	Power amplifier.
	V22	6AG7	Marker separator.
	V23	6AG5	Marker detector.
	V24	6AG5	Gate shaper.
	V25	6AG7	Gate amplifier.
	V26	6AG5	Inverter.
	V27	6AG7	Gate amplifier.
	V28	0B2	105-volt supply.
MODEM	V1	12AT7WA	Audio amplifier and ppm modulator.
	V2	12AT7WA	Clipper shaper and mixer.
	V3	12AT7WA	Gate generator and pwm converter.
	V4	12AT7WA	Clipper and audio output.
	V5	12AT7WA	D-c amplifier and ringing relay control.
VOLTAGE REGULATOR	V1	5727/2D21W	Motor drive.
	V2	5727/2D21W	Motor drive.
OSCILLOSCOPE	V1	2X2A	+1,800-volt rectifier.
	V2	2X2A	—1,500-volt rectifier.
	V3	6X4W	+450-volt rectifier.
	V4	6005/6AQ5W	+450-volt series regulator.
	V5	6AG5	+450-volt regulating amplifier.
	V6	5R4WGY	+225-volt rectifier.
	V7	5R4WGY	+225-volt rectifier.
	V8	6X4W	—140-volt rectifier.
	V9	6AS7G	+225-volt series regulator.
	V10	6AG5	+225-volt regulating amplifier.
	V11	0A2	—140-volt regulator.
	V12	6AG7	Vertical input amplifier.
	V13	6AG7	Cathode follower.
	V14	6AG7	Push-pull vertical output.
	V15	6AG7	Push-pull vertical output.
	V16	12AT7WA	8-kc and phase shift amplifier.
	V17	6AG7	Phase splitter sync amplifier.
	V18	6AG7	Sync amplifier.
	V19	5726/6AL5W	Trigger coupler and blanking restorer.
	V20	6AG7	Multivibrator.
	V21	6AG7	Multivibrator.
	V22	6AG7	Sawtooth sweep generator.
	V23	6005/6AQ5W	Sweep control.
	V24	5726/6AL5W	Horizontal output and d-c restorer.
	V25	6AU6	Push-pull horizontal output.
	V26	6AU6	Push-pull horizontal output.
	V27	12AT7WA	Crt blanking and unblanking buffer amplifier.
	V28	12AT7WA	Timing pip phase amplifier.
	V29	5726/6AL5W	Discriminator.
	V30	12AT7WA	Reactance modulator and 192-kc oscillator.
	V31	12AT7WA	192-kc amplifier and differentiating shaper.
	V32	5CP1A	Crt.
AUDIO TEST SET	V1	6AG5	Oscillator.
	V2	6AG5	Amplifier.
	V3	12AT7	Phase inverter.
	V4	12AT7	Push-pull amplifier.
	V5	12AT7	Limiter.
	V6	12AT7	Amplifier.
	V7	12AT7	Amplifier.
	V8	5R4WGY	Rectifier.
	V9	0A2	Voltage regulator.

CHAPTER 5

AUXILIARY EQUIPMENT

100. General

a. Multiplexer Group AN/TCA–1 is part of a transportable multichannel radio communication system. It is used in conjunction with Multiplexer Set AN/TCC–13 (terminal equipment), which modulates and multiplexes up to 23 channels of audio information into a single pulse train. This pulse train is then fed to a radio-frequency link, which transmits the signal to the desired terminal by means of a series of repeaters. At this terminal, the pulse train is fed to another multiplexer set that demultiplexes and demodulates it into the original number of channels of audio information. At the repeater point, the signal is fed into Multiplexer Group AN/TCA–1, which reshapes the signal into its original configuration. At this point it is also possible to drop up to eight channels from the transmitted pulse train by means of drop channel facilities, and to insert eight new signals if desired. Multiplexer Set AN/TCC–13, the radio-frequency link (Radio Set AN/TRC–29), and Pulse Form Restorer Group AN/TRA–10 are not part of the multiplexer group and are therefore not covered in this manual. However, a brief description of these units is given in this chapter.

b. The audio channels fed to, and obtained from, the multiplexer set are generally connected to a standard military switchboard. The switchboard is not part of the multiplexer set, and reference should be made to the manual that covers the switchboard used for information on it.

101. Radio-frequency Link (Radio Set AN/TRC–29)

Radio Set AN/TRC–29 is usually used to transmit and receive the pulse train output of the multiplexer set. The AN/TRC–29 consists basically of a transmitter rack (which accepts a pulse train signal and uses it to frequency-modulate a microwave signal), a receiver rack (which accepts a frequency-modulated microwave signal and detects the original pulse train), and an antenna system (which transmits and receives microwave signals). Refer to the applicable component manual for further information on Radio Set AN/TRC–29.

102. Multiplexer Set AN/TCC–13

Multiplexer Set AN/TCC–13 provides means for combining 23 independent v-f channels into a common video signal for transmission over a single r-f carrier; and conversely separates the common video signal into the 23 independent v-f channels. It thus provides for two-way communication over up to 23 telephone channels. Two multiplexer sets may be used to provide 45 simultaneous conversations. Refer to the applicable component manual for further information on Multiplexer Set AN/TCC–13.

103. Pulse Form Restorer Group AN/TRA–10

a. This group has essentially the same functions as the multiplexer group except that they are available on only channels 1 and 2.

(1) It reshapes the pulse train.

(2) It drops and inserts channels 1 and 2 of the positive pulse train.

b. No change in operational procedure is required.

c. Refer to the applicable component manual for further information on Pulse Form Restorer Group AN/TRA–10.

104. Use of AN/TCA–1 with Other Equipment

Multiplexer Group AN/TCA–1 can be used with any radio equipment that can accept the video output signal of Multiplexer Set AN/TCC–13, in conjunction with which it is used. The characteristics that such a system must have are described in the applicable component manual for the multiplexer set.

105. Ppm System Alarm Considerations

a. Each of the three ppm equipments (AN/TRA–10, AN/TCC–13, and AN/TCA–1) contains alarm circuits to provide visual and audible alarms in the event of internal or external failure. With a few exceptions, the alarm circuit at each equipment is completely independent of other radio and video equipment and provides an alarm indication only at the station of internal or external failure. The alarm signal is not transmitted down the system. For example, failure at a repeater station using ppm equipment does not cause an alarm indication at the terminals. Instead, alarm circuitry within the ppm equipment bypasses the repeater equipment in the direction of failure so that a proper pulse signal is fed to the repeater radio equipment, and from there to the terminal.

b. Furthermore, the alarm indication is limited to the direction of failure. Thus, at each repeater, there is an *eastgoing* and *westgoing* alarm indication, and an *eastgoing* failure does not affect the *westgoing* signal or vice versa. At a terminal, an alarm signal is initiated by a failure in the demultiplexing equipment. None of the alarm circuits include a lockup feature, so that restoration of the correct signal automatically removes the alarm indication and returns the equipment to normal operation.

106. Remote Keying Considerations

The operation of the remote keying system is explained in paragraph 132.

107. System Alignment of Audio Levels

a. General. This system alignment procedure precludes a talking circuit in operation independent of the equipment until the channel 1 order-wire circuit is aligned. After the order-wire channel is available, connect a field Telephone EE–8–B to the PARTY LINE channel 1 binding posts at all repeaters and use the order-wire circuit as directed in paragraph 72.

b. Alignment of Channels 1 and 2 at Terminal and Repeater. Channels 1 and 2 of both Pulse Form Restorer Group AN/TRA–10 and Multiplexer Group AN/TCA–1 are aligned identically in the following manner:

(1) *At east terminal AN/TCC–13.*

(*a*) Set the control monitor test switch S1 in the SEND position.

(*b*) Turn the modem channel 1 selector switch S2 to the SR position.

(*c*) Place the remote keying unit in the NORMAL OPERATION position.

(2) *At repeater AN/TRA–10 or AN/TCA–1.*

(*a*) Set the modem channel 1 eastfacing and westfacing 2W-4W switch S1 in the 4W position.

(*b*) Place the remote keying unit in the NORMAL OPERATION position.

(*c*) Place the channel 1 PARTY LINE-PRIV switch in PARTY LINE position.

(*d*) Place the channel 1 D&I-THRU switch in the D&I position.

(*e*) At the AN/TCA–1 only, set the control monitor test switch S1 in the NORMAL position.

(3) *At east terminal AN/TCC–13.* At the east terminal AN/TCC–13, modulate channel 1 with full modulation (–4 dbm for four-wire (4W) and 0 dbm for two-wire (2W)).

(4) *At repeater AN/TRA–10 or AN/TCA–1.*

(*a*) Connect the oscilloscope and direct probe to the front panel OUTPUT TO WESTFACING XMTR test jack.

(*b*) Adjust the channel 1 modem OUTPUT AUDIO GAIN control R37 until a deviation of ±.5 usec is obtained on the oscilloscope.

(5) *At west terminal AN/TCC–13.*

(*a*) Place the remote keying unit in NORMAL OPERATION position.

(*b*) Set the control monitor test switch S1 in the REC position.

(*c*) Turn the channel 1 modem selector switch S2 to the RR position.

(6) *At west terminal AN/TCC–13.* At the west terminal AN/TCC–13, adjust the channel 1 modem OUTPUT AUDIO GAIN control R37 until a reading of 0 dbm for four-wire (4W) or a reading of –3 dbm for two-wire (2W) is obtained on the audio test set.

(7) *Alignment of channel 2.* Repeat the procedures outlined in subparagraph *b*(1) through (6) above for channel 2.

(8) *Alignment in other direction.* Repeat the procedures outlined in subparagraph *b*(1) through (7) above for the other direction of transmission.

c. Alignment of Channels 3 through 8 from Terminal to Repeater AN/TCA–1.

(1) *At the east terminal AN/TCC–13.*

(*a*) Set the control monitor test switch in the SEND position.

(*b*) Turn the channel 3 modem selector switch S2 to the SR position.

(2) *At repeater AN/TCA–1.*

(*a*) Set the control monitor test switch S1 in the REC position.

(*b*) Turn the eastfacing channel 3 modem selector switch S2 to the RR position.

(*c*) Place the eastfacing channel 3 D&I-THRU switch in the D&I position.

(3) *At east terminal AN/TCC–13.* At the east terminal AN/TCC–13, modulate channel 3 with full modulation (–4 dbm for four-wire (4W) or 0 dbm for two-wire (2W)).

(4) *At repeater AN/TCA–1.* At the repeater AN/TCA–1, adjust the eastfacing channel 3 modem OUTPUT AUDIO GAIN control R37 until a reading of 0 dbm for four-wire or a reading of –3 dbm for two-wire is obtained on the audio test set.

(5) *Alignment of channels 4 through 8.* Repeat the procedure outlined in subparagraph *c*(1) through (4) above for channels 4 through 8.

(6) *Alignment in opposite direction.* Repeat the procedures outlined in subparagraph *c*(1) through (5) above for the other direction of transmission (west).

d. Alignment of Channels 3 through 8 from Repeater AN/TCA–1 to Terminal.

(1) *At repeater AN/TCA–1.*

(*a*) Set the control monitor test switch S1 in the SEND position.

(*b*) Place the channel 3 eastfacing D&I-THRU switch in the D&I position.

(*c*) Turn the eastfacing channel 3 modem selector switch S2 to the SR position.

(2) *At east terminal AN/TCC–13.*

(*a*) Set the control monitor test switch S1 in the REC position.

(*b*) Turn the channel 3 modem selector switch S2 to the RR position.

(3) *At repeater AN/TCA–1.* At the repeater AN/TCA–1, modulate the eastfacing channel 3 with full modulation (–4 dbm for four-wire (4W) or 0 dbm for two-wire (2W)).

(4) *At east terminal AN/TCC–13.* At the east terminal AN/TCC–13, adjust the channel 3 modem OUTPUT AUDIO GAIN control R37 until a reading of 0 dbm for four-wire or a reading of –3 dbm for two-wire is obtained on the audio test set.

(5) *Alignment of channels 4 through 8.* Repeat the procedures outlined in subparagraph *d*(1) through (4) above for channels 4 through 8.

(6) *Alignment for opposite direction.* Repeat the procedures outlined in subparagraph *d*(1) through (5) above for the other direction of transmission (west).

108. System Alignment of Video Levels

a. General. When Radio Set AN/TRC–29, Multiplexer Set AN/TCC–13, and Pulse Form Restorer Group AN/TRA–10 or Multiplexer

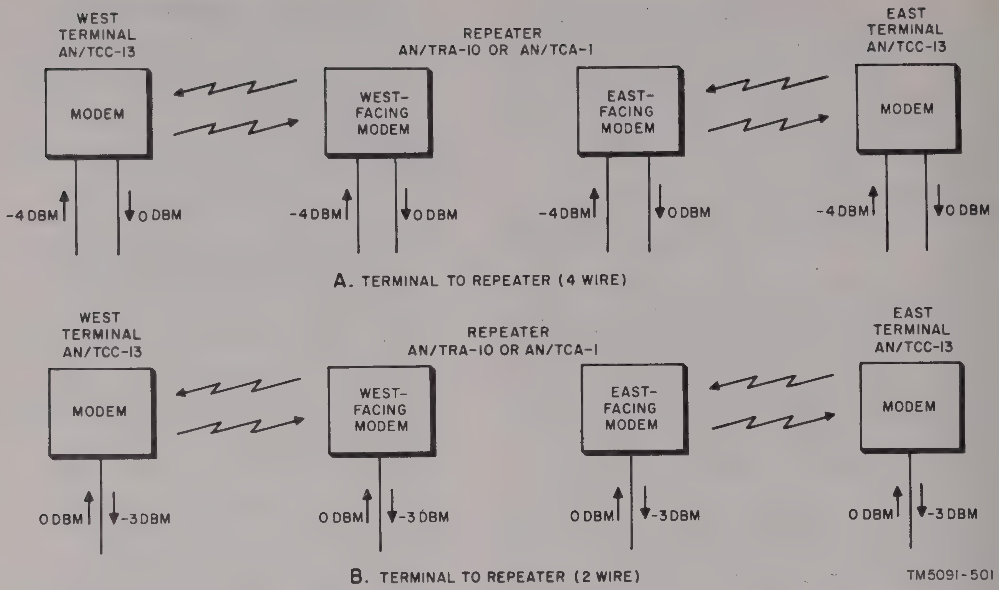

WEST TERMINAL AN/TCC-13
MODEM
REPEATER AN/TRA-10 OR AN/TCA-1
WEST-FACING MODEM
EAST-FACING MODEM
EAST TERMINAL AN/TCC-13
MODEM
-4 DBM
0 DBM
A. TERMINAL TO REPEATER (4 WIRE)
WEST TERMINAL AN/TCC-13
MODEM
REPEATER AN/TRA-10 OR AN/TCA-1
WEST-FACING MODEM
EAST-FACING MODEM
EAST TERMINAL AN/TCC-13
MODEM
0 DBM
-3 DBM
B. TERMINAL TO REPEATER (2 WIRE)
TM5091-501

Figure 104. System audio levels, private operation.

Group AN/TCA-1 are set up in a multihop radio-relay link (fig. 106), the following video level requirements will result in optimum operation of the system. Set all transmitters for 100 per cent modulation with video input levels as follows:

(1) Set all Multiplexer Set AN/TCC-13 video input and output levels at .5 volt.

(2) Set the output video level of each individual Pulse Form Restorer Group AN/TRA-10 and Multiplexer Group AN/TCA-1 to one-half of its input video level.

Note. Difficulty will be found only under the extreme condition of exceedingly long lengths of cable between equipments and under certain conditions of 45-channel operation.

b. Operation, 23-channel.

(1) *Normal operating conditions.* Align the system video levels as follows:

(*a*) At the east terminal Multiplexer Set AN/TCC-13, adjust the OUTPUT AMPL potentiometer so that there is a base line to peak amplitude of .5 volt at the front panel MASTER OUTPUT TO RF test jack.

(*b*) At the east terminal Radio Set AN/TRC-29, adjust the transmitter video input level control to obtain 100 per cent modulation.

(*c*) At the repeater station, observe the wave form on the AN/TRA-10 or AN/TCA-1 at the INPUT FROM EASTFACING REC test jack, and adjust the video output level control on the eastfacing receiver for a base line to peak pulse amplitude of .5 volt.

(*d*) At the AN/TRA-10 or AN/TCA-1 repeater station, set the westgoing video restorer P.T. OUT AMPL switch S2 in the LOW position, and adjust the westgoing video restorer SYM ADJ potentiometer R33 for a base line to peak pulse train amplitude of .25 volt at the OUTPUT TO WESTFACING XMTR test jack.

(*e*) At the repeater station Radio Set AN/TRC–29, adjust the video input level control on the westfacing transmitter for 100 per cent modulation.

(*f*) At the west terminal Radio Set AN/TRC–29, adjust the video output level control so that the base line to peak pulse amplitude at Multiplexer Set AN/TCC–13 MASTER INPUT FROM RF test jack is .5 volt.

(*g*) Repeat the procedures outlined in subparagraphs (*a*) through (*f*) above for the other direction of transmission.

(2) *Nonoptimum operating conditions.* The nonoptimum operating conditions of the AN/TRA–10 or AN/TCA–1 (such that cause lower than .5-volt pulse amplitude input to the AN/TRA–10 or AN/TCA–1) may be caused by an exceedingly long cable length between the AN/TRA–10 or AN/TCA–1 and Radio Set AN/TRC–29. Under this condition, set the video level of the system as follows:

(*a*) At the east terminal Multiplexer Set AN/TCC–13, adjust the OUTPUT AMPL potentiometer R74 so that the base line to peak pulse

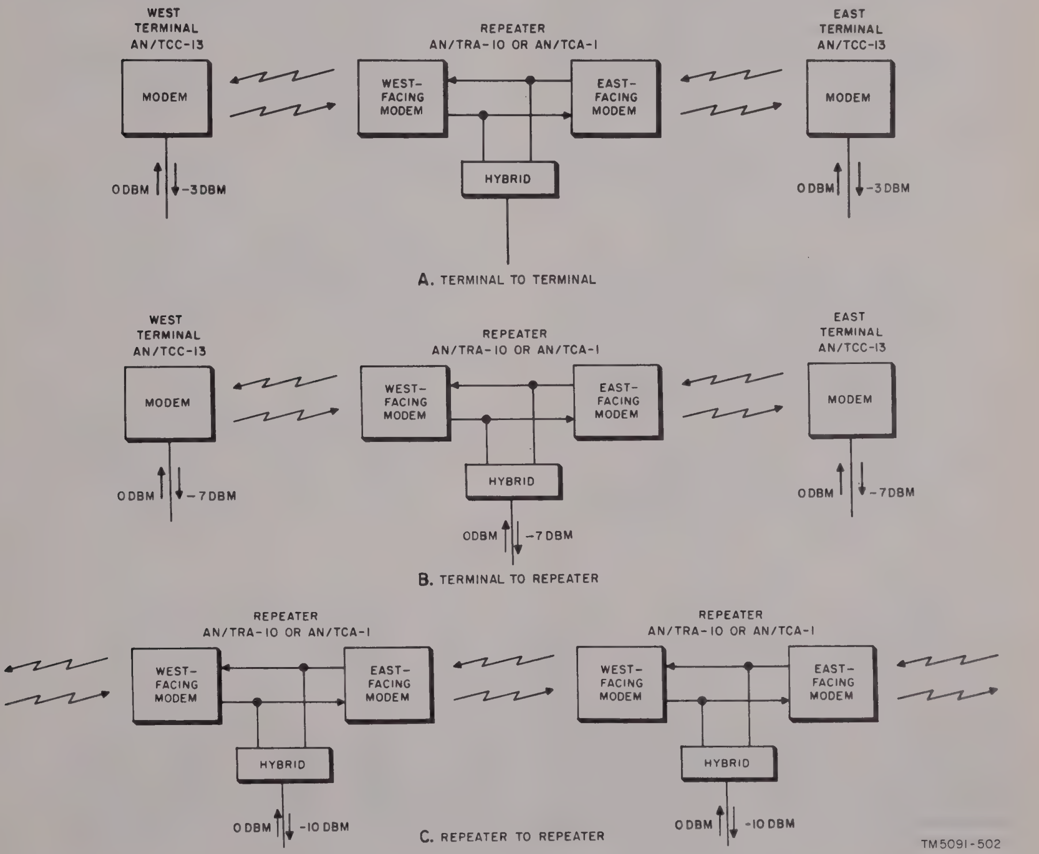

WEST TERMINAL AN/TCC-13
MODEM
REPEATER AN/TRA-10 OR AN/TCA-1
WEST-FACING MODEM
EAST-FACING MODEM
HYBRID
EAST TERMINAL AN/TCC-13
MODEM
0 DBM
-3 DBM
0 DBM
-3 DBM
A. TERMINAL TO TERMINAL
WEST TERMINAL AN/TCC-13
MODEM
REPEATER AN/TRA-10 OR AN/TCA-1
WEST-FACING MODEM
EAST-FACING MODEM
HYBRID
EAST TERMINAL AN/TCC-13
MODEM
0 DBM
-7 DBM
0 DBM
-7 DBM
0 DBM
-7 DBM
B. TERMINAL TO REPEATER
REPEATER AN/TRA-10 OR AN/TCA-1
WEST-FACING MODEM
EAST-FACING MODEM
HYBRID
0 DBM
-10 DBM
REPEATER AN/TRA-10 OR AN/TCA-1
WEST-FACING MODEM
EAST-FACING MODEM
HYBRID
0 DBM
-10 DBM
C. REPEATER TO REPEATER
TM5091-502

Figure 105. System audio levels, party-line operation.

amplitude at the front panel MASTER OUTPUT TO RF test jack is .5 volt.

Note. If the video cable between the AN/TCC–13 and the AN/TRC–29 is very long, it may not be possible to modulate 100 per cent with an output of .5 volt from the AN/TCC–13. If this occurs, adjust the output of the AN/TCC–13 for 100 per cent modulation.

(*b*) At the east terminal Radio Set AN/TRC–29, adjust the transmitter video input level control to obtain 100 per cent modulation.

(*c*) At the repeater station, observe the wave form on the AN/TRC–10 or the AN/TCA–1 at the INPUT FROM EASTFACING REC test jack and adjust the video output level control at the eastfacing receiver for a maximum input pulse level.

(*d*) At the repeater station AN/TRA–10 and/or AN/TCA–1, set the westgoing P.T. OUT AMPL switch S2 in the HIGH position.

(*e*) With the field telephone, contact personnel at the westfacing transmitter and adjust the westgoing SYM ADJUST potentiometer R33 on the AN/TRA–10 or AN/TCA–1 for as low a level as possible to modulate the transmitter 100 per cent.

(*f*) At the west terminal Radio Set AN/TRC–29, adjust the video output level control so that the base line to peak pulse amplitude at the AN/TCC–13 MASTER INPUT FROM RF test jack is .5 volt.

(*g*) Repeat the procedures outlined in subparagraphs (*a*) through (*f*) above for the other direction of transmission.

c. Operation, 45-channel.

(1) *Normal operation.* Align the system video levels as follows:

(*a*) At the east *master* and *slave* terminal Multiplexer Sets AN/TCC–13, adjust each (*master* and *slave*) OUTPUT AMPL potentiometer R74 so that the base line to positive peak and base line to negative peak pulse amplitude at the front panel OUTPUT TO RF test jack on the *master* Multiplexer TD–60/G are .5 volt each.

(*b*) At the east terminal *master* Multiplexer Set AN/TCC–13, adjust 45 CHAN PHASE potentiometer R3 until the spacing between the second positive marker pulse and the second negative marker pulse is 2.6 usec.

(*c*) At the east terminal Radio Set AN/TRC–29, adjust the transmitter video input level control to obtain 100 per cent modulation. (Positive and negative should be within 10 per cent of each other.)

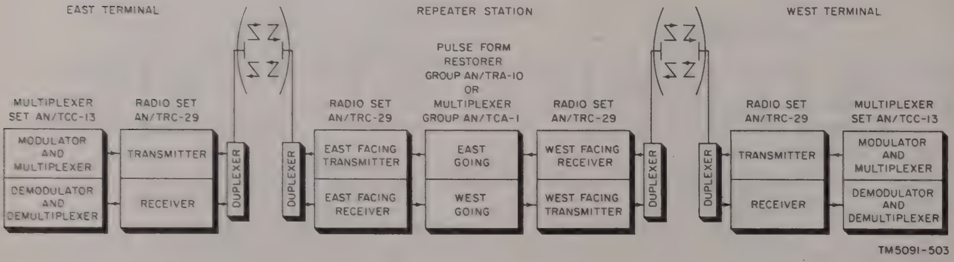

EAST TERMINAL
REPEATER STATION
WEST TERMINAL
PULSE FORM RESTORER GROUP AN/TRA-10 OR MULTIPLEXER GROUP AN/TCA-1
MULTIPLEXER SET AN/TCC-13
RADIO SET AN/TRC-29
RADIO SET AN/TRC-29
RADIO SET AN/TRC-29
RADIO SET AN/TRC-29
MULTIPLEXER SET AN/TCC-13
MODULATOR AND MULTIPLEXER
DEMODULATOR AND DEMULTIPLEXER
TRANSMITTER
RECEIVER
DUPLEXER
DUPLEXER
EAST FACING TRANSMITTER
EAST FACING RECEIVER
EAST GOING
WEST GOING
WEST FACING RECEIVER
WEST FACING TRANSMITTER
DUPLEXER
DUPLEXER
TRANSMITTER
RECEIVER
MODULATOR AND MULTIPLEXER
DEMODULATOR AND DEMULTIPLEXER
TM5091-503

Figure 106. Multihop radio-relay link, block diagram.

(*d*) At the repeater station, observe the wave form on the AN/TRA–10 or AN/TCA–1 at the INPUT FROM EASTFACING REC test jack and adjust the video output level control on the eastfacing receiver for a peak pulse train amplitude of 1 volt.

(*e*) At the repeater station AN/TRA–10 or AN/TCA–1 westgoing side, place 23 CHAN-45 CHAN switch S1 in the 45 CHAN position, P.T. OUT AMPL switch S2 in the LOW position, and adjust SYM ADJ potentiometer R33 for a symmetrical pulse train (that is, positive and negative pulse train of equal amplitude) at the OUTPUT TO WESTFACING XMTR test jack.

(*f*) At the repeater Radio Set AN/TRC–29, adjust the video input level control on the westfacing transmitter for 100 per cent modulation.

(*g*) At the west terminal Radio Set AN/TRC–29, adjust the video output level control so that the peak-to-peak pulse train amplitude at the Multiplexer Set AN/TCC–13 MASTER INPUT FROM RF test jack is 1 volt.

(*h*) Repeat the procedures outlined in subparagraphs (*a*) through (*g*) above for the other direction of transmission.

(2) *Nonoptimum operating conditions.* The nonoptimum operating conditions of the AN/TCA–1 or AN/TRA–10 are those that cause lower than 1-volt peak-to-peak pulse amplitude input to the AN/TRA–10 or AN/TCA–1. These may be caused by exceedingly long cable lengths between the AN/TRA–10 or AN/TCA–1 and the r-f equipment (AN/TRC–29) or insufficient output from the receiver of the r-f equipment. Under these conditions, set the system video levels as follows:

(*a*) Proceed as directed in subparagraph (1) (*a*) through (*c*) above. Note that if the video cable between the AN/TCC–13 and the AN/TRC–29 is very long it may not be possible to modulate 100 per cent with .5-volt output from the AN/TCC–13. If this occurs, make the output from the AN/TCC–13 large enough to be able to get 100 per cent modulation.

(*b*) At the repeater station, observe the wave form on the AN/TRA–10 or AN/TCA–1 at the front panel INPUT FROM EASTFACING REC test jack and adjust the video output level control on the eastfacing receiver for a maximum peak-to-peak level.

(*c*) At the repeater station AN/TRA–10 or AN/TCA–1 westgoing side, place 23 CHAN-45 CHAN switch S1 in the 45 CHAN position, P.T. OUT AMPL switch S2 in the HIGH position, and adjust SYM ADJ potentiometer R33 for a symmetrical pulse train at the OUTPUT TO WESTFACING XMTR test jack.

(*d*) Perform the adjustments described in subparagraph (1) (*f*) through (*h*) above. If the amplitude into the AN/TCC–13 is too small, set the AN/TRC–29 receiver video output level control for maximum.

CHAPTER 6

THEORY OF OPERATION

Section I. SYSTEM THEORY

109. General

a. Multiplexer Group AN/TCA-1 is a transportable equipment designed to provide reshaping of the 23- or 45-channel ppm pulse train received from the radio receiver in a radio link before it is fed to the radio transmitter at a repeater station. It can also be used to drop and insert eight channels at the radio-relay site; this enables the repeater station to communicate with either terminal or another relay site.

b. Since communication is normally conducted in two directions through a repeater station, identical facilities are provided, one for each direction of communication. However, since the two sections, eastgoing and westgoing, of the multiplexer group are mechanically and electrically identical, only one section will be considered in the following discussion.

c. The drop and insert channels are supplied so that the operator at the repeater may elect to drop (remove) signals being received on channels 1 through 8, and locally insert a signal which then replaces the removed signal and travels on as part of the regular pulse train. The inserted signals take the place of the dropped ones and appear identical with signals from the original point of transmission.

d. The pulses in the received pulse train may vary in shape. One function of the video restorer is to make all pulses uniform and of the shape described in paragraph 110*b*.

e. An over-all block diagram of the multiplexer group is shown in figure 107. For through signals, with no channels dropped or inserted at the repeater, the incoming pulse train is fed to both the positive and negative pulse train reshapers. The pulses are reshaped to the desired level and fed to the output, where they are applied to the transmitter for retransmission. A switch, which enables the operator to disconnect the negative pulse train reshaper filaments when the equipment is used in a 23-channel system, is provided. If the operator wishes to drop and insert eight channels, the first eight pulses of the received positive train are dropped and the locally generated signal pulses are inserted. The blank and insert circuits of the video restorer feed the first eight pulses to demultiplexer and demodulator circuits that transform the pulses into usable audio information. The audio signals to be inserted are fed to the modulator and multiplexer circuits that transform them into pulse-position-modulated pulses. The pulses are then inserted into the pulse train by the insert circuit. As seen in figure 107, the negative pulse train reshaper reshapes the negative pulse train and feeds it directly to the system output. The positive pulse train reshaper, however, is broken into two sections. The positive pulse train is fed through the first section and then is tapped off and passes through the blank and insert channels before going to the second section and the output. In addition, the positive signals are also fed to the demultiplexer and demodulator. Inserted signals are fed through the multiplexer and modulator and then directly to the second section and the output.

110. Reshaping Circuit

a. The simplest function of the pulse form restorer group is to reshape the pulses without dropping or inserting any signals. This function is carried out by the reshaper section of the video restorer. Tubes V1 through V5 provide negative pulse train reshaping, while tubes V6 through V10 provide positive pulse train reshaping. The reshaping section will:

(1) Reshape the 23- or 45-channel pulse train to a standard waveshape for both directions of transmission.

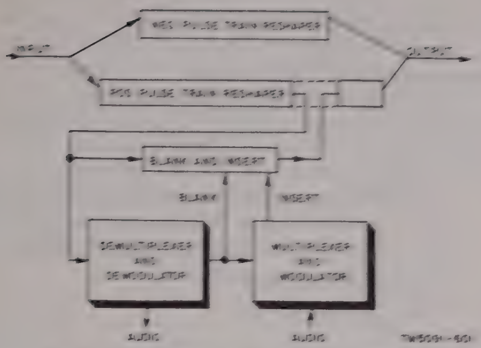


Figure 107. Multiplexer Group AN/TCA-1, over-all block diagram.

(2) Bypass the input to the output in the event of unit failure and actuate the alarm circuit.

(3) Provide an 8-kc sine wave for synchronization of the oscilloscope.

Note. These functions apply to signals in either direction.

b. The video restorer must accept a pulse train that is nominally .5 volt peak from the r-f receiver. If the pulse train is a composite one (45-channel operation) consisting of two 23-channel pulse trains, one of which is the opposite polarity from the other and interleaved, the amplitude of the composite will be nominally 1 volt peak-to-peak; that is, each pulse train in the composite will be nominally .5 volt peak. Each pulse train in the composite may vary from .3 to .7 volt peak, independently, and the overshoot of either pulse train in the composite cannot exceed 30 per cent of the amplitude of the other pulse train. The input impedance of the unit is 50 ohms ±10 per cent. The width of the pulses in the input pulse train will be nominally .5 microsecond but may vary from .3 to .7 microsecond. The pulse train described above must be reshaped to a standard waveshape and fed to a 50-ohm output impedance with an amplitude that is at least .7 volt peak (1.4 volts peak-to-peak for a composite 45-channel pulse train). The standard waveshape is as follows: the width of each pulse should be .5 ±.2 microsecond measured at the 50 per cent amplitude point.

111. Demultiplexing and Demodulating Circuit

(fig. 108)

a. When the local operator elects to drop and insert a signal, the video restorer performs all the operations described in paragraph 110. In addition, the video restorer provides the proper pulses to the eight modems (for each direction of transmission) to allow demodulation of channels 1 to 8 of the positive pulse train. On reception, the positive pulse train is taken from the positive reshaper and fed into the blanking circuits. It is also fed to the pulse amplifier and then to the gate generator. The gate generator output is sent through the delay line to provide channel separation signals that are fed back to the demodulator circuits. The pulse train is also fed into the demodulators, and the resultant audio signal taken from there.

b. The following video restorer waveshapes are necessary for demodulation of the dropped channels in the modems.

(1) The entire positive pulse train must be available from an impedance source of less than 400 ohms. The positive pulse train must be changed to a negative polarity with an amplitude of 35 volts ±10 per cent. The waveshape at this point represents a 10 per cent or smaller slice from the center portion of the input pulse train to achieve the maximum signal-to-noise advantage. Therefore, it must also have been differentiated to remove any noise that may be present on the trailing edges of the pulses (par. 120*d*).

(2) A negative gate must be supplied to the delay line (which is terminated in 3,000 ohms). The amplitude of this gate must be 130 ±10 volts and should be nominally 4 microseconds wide (±10 per cent) measured at the 50 per cent amplitude point. The delay line is not part of the video restorer; it is made sufficiently long in delay to provide suitable selecting gates to the demodulators in the modems, by adding sections. It is located on the rack.

c. An 8-kc sine wave, which is synchronous with the incoming pulse train for the purpose of synchronizing the oscilloscope, must be obtained.

112. Modulating and Multiplexing Circuit

a. General (fig. 109). When a signal is to be modulated and multiplexed, the video restorer performs the following functions in addition to those already listed:

(1) Provides the proper waveshapes to eight modems for each direction of transmission to allow generation and modulation of eight new channel pulses to be inserted in the pulse trains.

(2) Accepts eight pulses for each direction of transmission from these modems and inserts them in the outgoing pulse trains in place of the pulses that have been blanked. During insert, the positive pulse train is taken from the reshaper and fed to the blank and insert sections. It is also amplified in the pulse amplifier, and then used to produce gates in the gate generator and inverter. These gates are fed to the delay line, and the delayed signals then go to the channel modulators and control pulses that are fed to the insert channel and back into the positive pulse train reshaper.

b. Modem Modulator.

(1) The audio information to be relayed is applied to the eight individual modems, using either a two- or four-wire connection. The modems act on this audio-frequency (a-f) signal to pro-

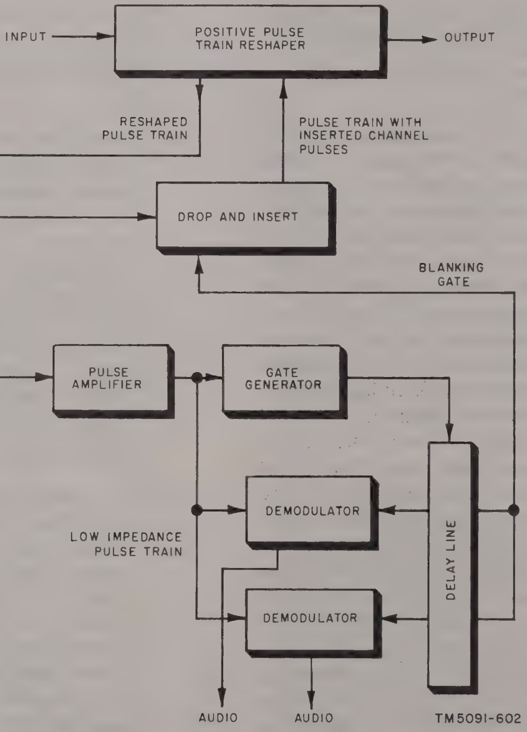

INPUT
POSITIVE PULSE TRAIN RESHAPER
OUTPUT
RESHAPED PULSE TRAIN
PULSE TRAIN WITH INSERTED CHANNEL PULSES
DROP AND INSERT
BLANKING GATE
PULSE AMPLIFIER
GATE GENERATOR
DEMODULATOR
LOW IMPEDANCE PULSE TRAIN
DEMODULATOR
DELAY LINE
AUDIO
AUDIO
TM5091-602

Figure 108. Demultiplexing and demodulating circuit, block diagram.

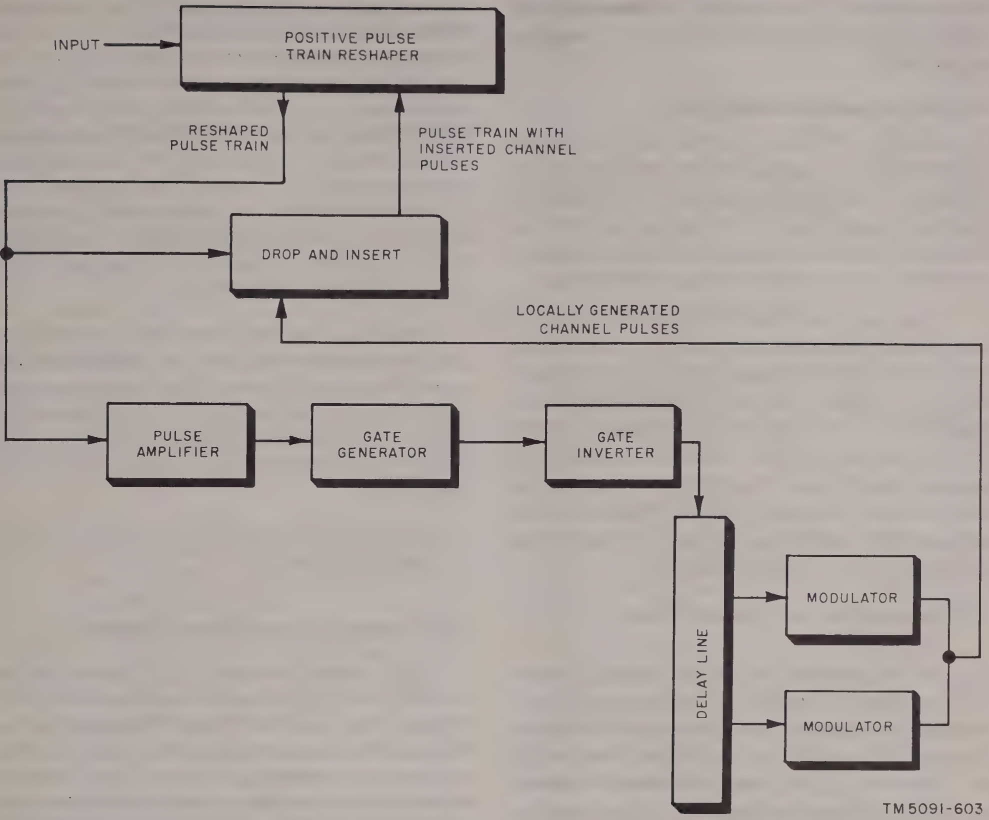

INPUT
POSITIVE PULSE TRAIN RESHAPER
RESHAPED PULSE TRAIN
PULSE TRAIN WITH INSERTED CHANNEL PULSES
DROP AND INSERT
LOCALLY GENERATED CHANNEL PULSES
PULSE AMPLIFIER
GATE GENERATOR
GATE INVERTER
DELAY LINE
MODULATOR
MODULATOR
TM 5091-603

Figure 109. Modulating and multiplexing circuit, block diagram.

duce ppm channel pulses. Refer to paragraph 36 for the principles of ppm and to paragraph 113 for a description of ppm.

(2) The video restorer provides means to blank (drop) channels 1 to 8 of the positive pulse train in each direction of transmission to allow new channel pulses locally generated and modulated to be inserted in their place. These inserted signals are generated and modulated in the eight-channel modems for the two directions of transmission. The video restorer provides the proper waveshapes for these modems. The ppm pulses from the modems are then inserted by the video restorer in the outgoing wave train.

c. Waveshape Supplied to Modem for Modulation. The modulator in each modem must receive a positive sawtooth which is 8 microseconds wide and 20 volts peak in order to generate and allow modulation of a new channel pulse. To accomplish this, the video restorer must supply a positive gate which is 100 to 110 volts in amplitude and 8 ±1 microseconds wide at 50 per cent amplitude. This gate should correspond in time to the marker pulse in the input pulse train. The proper phasing for eight channels and the proper sawtooth waveshape are provided by the delay line (not part of the video restorer). The sawtooth waveshape is obtained from the delay line outputs by integrating circuits.

113. Pulse-position Modulation

a. General. When a carrier conveys audio information, the carrier must be changed, or modulated, according to the audio information. Various characteristics of the carrier may be modulated for this purpose. Multiplexer Group AN/TCA–1 uses pulse-position modulation.

b. Pulse-position Modulation. Pulse-position modulation consists of converting the information, such as an a-f signal, into a pulse-position-modulated signal. (Refer to paragraph 36 for principles of pulse-position modulation.) With no audio signal present, pulses are produced at constant intervals of time. When an audio signal is present, the time position relative to the unmodulated position is varied as a function of the amplitude of the audio signal.

114. Modulation of Channel Pulses
(fig. 22)

a. In the absence of an a-f signal, pulses from a given channel in the multiplexer set are produced at constant time intervals of 125 microseconds. Assume that a 1,000-cps audio signal (curve B, fig. 22) is used to position modulate these channel pulses. The time interval (period) for a full cycle of the 1,000-cps signal is 1,000 microseconds. During this cycle, eight channel pulses are formed at 125-microsecond intervals. Assume that the first pulse appears at the beginning of the cycle (curve C, fig. 22). The amount of time displacement is directly proportional to the amplitude of the modulating signal. When the amplitude of the sine wave is zero, the first pulse remains in its unmodulated position. By the time the second pulse is formed, however, the 1,000-cycle signal has become positive. The effect is to cause the second pulse to appear later than an unmodulated pulse. The sine wave reaches its maximum positive amplitude at the time of the third channel pulse, resulting in a maximum displacement of that pulse from its unmodulated position.

b. The sine wave now decreases in amplitude to zero, and the displacement of the fourth and fifth pulses accordingly decreases to zero. An increase in amplitude of the signal in the negative direction then causes the succeeding channel pulses to appear earlier than would the unmodulated pulses. This opposite displacement also is directly proportional to the amplitude of the sine wave. In this specific example, after 1,000 microseconds, the amplitude of the signal again is zero, and the cycle begins over again. The ninth pulse corresponds to the first pulse, thus beginning a new series.

c. The time interval between pulses in each channel of the multiplexer set is 125 microseconds. Since the 1,000-cps sine wave is sampled eight times during each cycle, each interval or period corresponds to a frequency of 8,000 cps. This is called the sampling rate, or scanning frequency.

d. Each of the channel pulses is modulated as described above.

115. Time-division-multiplex Operation

a. The signal consists of 23 channel pulses each of which is pulse-position modulated. It is necessary to combine these 23 signals so that all may be transmitted on one carrier. This is done by sampling each of the channels sequentially by means of sampling pulses separated in time. An appropriately designed demultiplexer can then separate the channels, demodulate each channel pulse series, and recover the original a-f signals.

b. Each complete pulse train fed to the transmitter consists of 23 channel pulses and a marker pulse. The marker pulse (B, fig. 23) is a double pulse. The pulse that occurs immediately after the marker pulse is called the channel 1 pulse (C), the next pulse is called the channel 2 pulse (D), and so on to the channel 23 pulse (F). Then another marker pulse is formed and the entire train is repeated.

c. The marker pulse and signal pulses in any one channel occur at 125-microsecond intervals, which is the time duration of 1 cycle at 8,000 cps. The individual channel pulses, therefore, occur only once in each frame.

d. In B, figure 23, the marker pulse starts the train. Assuming that the channel pulses are unmodulated, the channel 1 pulse occurs 5.2 microseconds after the leading edge of the second marker pulse. The time is measured from the leading edge of the second marker pulse to the leading edge of the channel 1 pulse. After 5.2 microseconds, the channel 2 pulse occurs. After another 5.2 microseconds, the channel 3 pulse occurs, and so on up to the channel 23 pulse (at F). After 5.2 microseconds, the occurrence of the channel 23 pulse, the second marker pulse appears, and the entire pulse train is repeated. The time, T, for one pulse train is 125 microseconds.

e. The channel pulses and the marker pulses taken together are called the pulse train, or the multiplex pulse train. The number of channels can be as many as the equipment permits.

f. Forty-five-channel operation is obtained by applying the time division principle to mixing the two 23-channel pulse trains; that is, a 23-channel positive pulse train and a 23-channel negative pulse train are added together with a delay so that they are equally spaced. One channel is deleted to add a marker pulse.

g. To prevent interference (cross talk) between successive channels, the amount of modulation (delay or advance) of a channel pulse is limited to .5 microsecond. Limiting action starts at .5 microsecond, but overmodulation will cause a greater deviation.

116. Blanking and Insert

a. General. The video restorer is capable of blanking any of the first eight channels of the positive pulse train sufficiently well so that the signal-to-cross talk ratio, when measured from a modulated pulse which is blanked to a new pulse which is inserted in its place, is not worse than 55 db. This type of cross talk is called *feedthrough cross talk.* The video restorer provides facilities for inserting a new pulse into the pulse train after having blanked the original pulse. This action is shown in figure 109, and is explained in paragraph 112*a*.

b. Insertion of Channel Pulses into Pulse Train. The video restorer provides a common resistance of 470 ohms in which to mix the channel pulses from the modulators of the local modems. It also provides +11 volts dc across this resistor in order to properly bias the cathode follower outputs in each modem. The pulses existing at this point will be 4 to 7 volts peak and will have varying widths. These pulses must be inserted in the positive pulse train in place of the blanked channel pulses, *and must have the same shape and amplitude as the other pulses at the output of the video restorer.*

117. Power Supplies

The power supply for the multiplexer group consists of Voltage Regulator CN–236/G, Multiplexer Subassembly MX–1442/TC (filament supply), and Power Supply PP–691/G (B+ supply).

a. Voltage Regulator CN–236/G. The voltage regulator is an electromechanically controlled voltage regulator that delivers a constant output independent of line voltage or load current. An autotransformer with 115- or 230-volt operation is included.

b. Power Supply PP–691/G. The power supply is the main B+ power supply and provides +250 volts dc with a total capacity of 1.6 amperes. It also acts as the main a-c power input chassis and contains the main a-c power and plate circuit breakers.

c. Multiplexer Subassembly MX–1442/TC. The multiplexer subassembly contains two 6.3-volt filament transformers for the filament supply of the multiplexer set. In addition, it contains a blower that provides cooling for the modem units directly above it and two remote keying units that plug into receptacles mounted on the rear of the multiplexer subassembly.

118. Test Equipment

a. General. The accessory test equipment necessary to perform maintenance and alignment of the multiplexer group is mounted in one test rack. The accessory test equipment comprises Audio Test Set TS–762/TC, Control Monitor C–1151/TC, and Oscilloscope OS–25/G.

b. Audio Test Set TS–762/TC. This test set is a general purpose a-c operated instrument, designed for the measurement of voice trans-

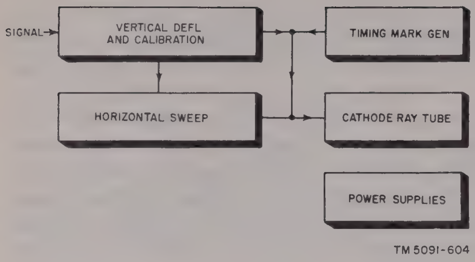


Figure 110. Oscilloscope OS–25/G, functional block diagram.

mission systems. The test set incorporates extra connectors for particular use with the multiplexer set. Refer to paragraph 143 for a detailed description of each of these functional circuits. The audio test set provides four fundamental functions:

(1) A low-distortion, variable output, 1,000-cycle oscillator.

(2) A 1,000-cycle level measuring meter.

(3) A 1,000-cycle distortion measuring circuit.

(4) A noise-measuring circuit with F1A line weighting.

c. Control Monitor C–1151/TC. Refer to paragraph 144 for a detailed description of each of the control monitor circuits. This unit contains the following:

(1) Circuitry and a telephone headset to provide an order-wire telephone.

(2) A push-button switch circuit, which, associated with the test set, facilitates testing of the 23 audio channels.

(3) A 20-cycle ringing supply.

d. Oscilloscope OS–25/G (fig. 110). This unit is a 5-mc bandwidth oscilloscope that meets the requirements for the maintenance and alignment of the various sections of the multiplexer group. It differs from the ordinary test oscilloscope because it includes a continuously variable phase synchronizing circuit and 5.2-microsecond timing pips for the alignment of the unmodulated channel pulses. In addition, it may be used as a high quality, general purpose, wide-band oscilloscope for trouble shooting. The oscilloscope (par. 137) consists of a vertical deflection amplifier, timing mark generator, horizontal sweep, cathode-ray tube, and power supply circuits. The vertical deflection and calibration circuits amplify the input signal and tap off a 60-cycle signal for a voltage calibration by comparison. The horizontal sweep provides horizontal deflection for the cathode-ray tube. A timing mark generator provides calibrated crt time signals. Power supplies for all circuits are also included.

Section II. THEORY OF VIDEO RESTORER

119. General

a. Before making a detailed discussion of the circuitry involved, refer to the video restorer block diagram (fig. 111) and the over-all schematic diagram (fig. 260). Note that the block diagram is divided into sections, each of which performs one or more of the desired functions. Stages V1 through V5B provide reshaping of the negative part of the pulse train if the input is a 45-channel composite pulse train. Stages V6 through V10 provide reshaping of the positive part of the pulse train. As shown in the block diagram, the composite signal appears at the input, and the negative and positive components are separated and reshaped in their respective reshaper sections. Transformer T1 provides mixing of the two reshaped pulse trains to re-form the 45-channel composite as shown at the output, and it also provides matching of the two pulse output tubes, V5B and V10B, to the 50-ohm output load. Stage V11 provides blanking of one to eight channels from the positive pulse train; stage V12 provides for shaping of the channel pulses generated in the local modems and mixes them with the pulse train that has had channels blanked from it. Stage V13 provides a low source impedance from which to drive the shaped blanking gates into stage V11 for

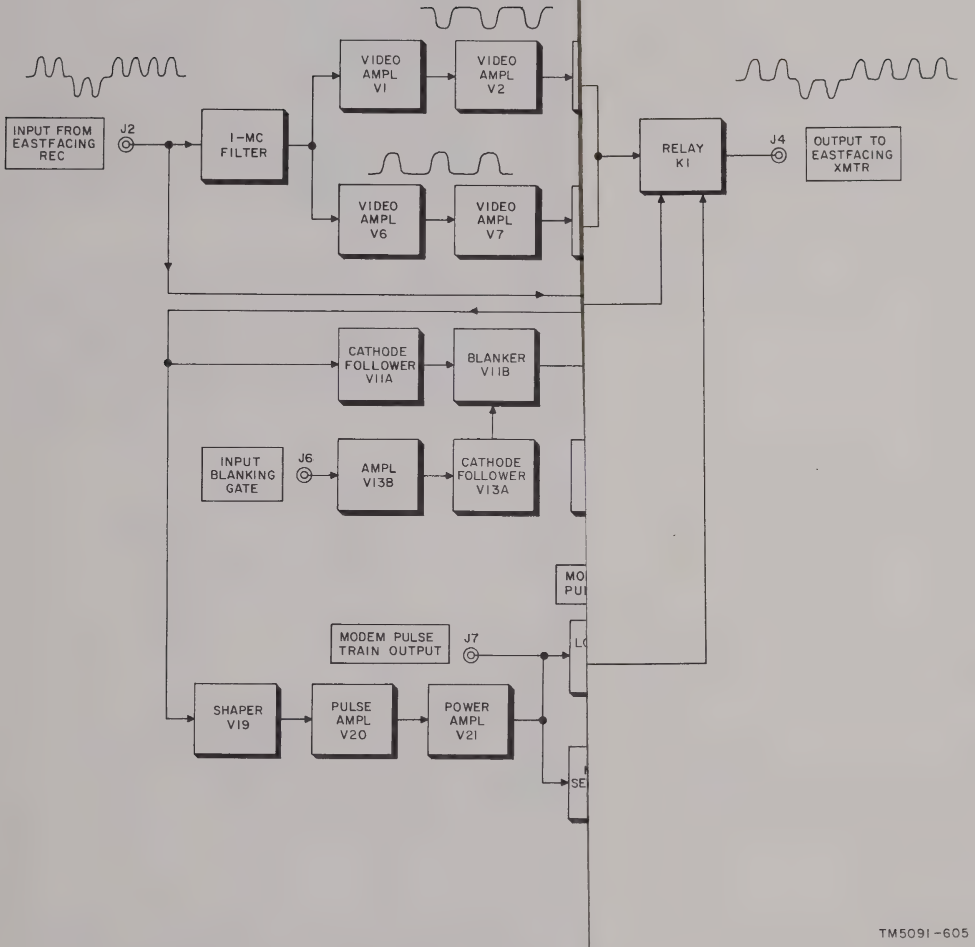

INPUT FROM EASTFACING REC
J2
1-MC FILTER
VIDEO AMPL V1
VIDEO AMPL V2
VIDEO AMPL V6
VIDEO AMPL V7
RELAY K1
J4
OUTPUT TO EASTFACING XMTR
CATHODE FOLLOWER V11A
BLANKER V11B
INPUT BLANKING GATE
J6
AMPL V13B
CATHODE FOLLOWER V13A
MODEM PULSE TRAIN OUTPUT
J7
SHAPER V19
PULSE AMPL V20
POWER AMPL V21
TM5091-605

Figure 111. Video restorer, over-all block diagram.

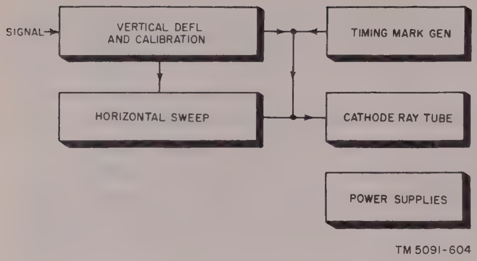


Figure 110. Oscilloscope OS–25/G, functional block diagram.

mission systems. The test set incorporates extra connectors for particular use with the multiplexer set. Refer to paragraph 143 for a detailed description of each of these functional circuits. The audio test set provides four fundamental functions:

(1) A low-distortion, variable output, 1,000-cycle oscillator.

(2) A 1,000-cycle level measuring meter.

(3) A 1,000-cycle distortion measuring circuit.

(4) A noise-measuring circuit with F1A line weighting.

c. Control Monitor C–1151/TC. Refer to paragraph 144 for a detailed description of each of the control monitor circuits. This unit contains the following:

(1) Circuitry and a telephone headset to provide an order-wire telephone.

(2) A push-button switch circuit, which, associated with the test set, facilitates testing of the 23 audio channels.

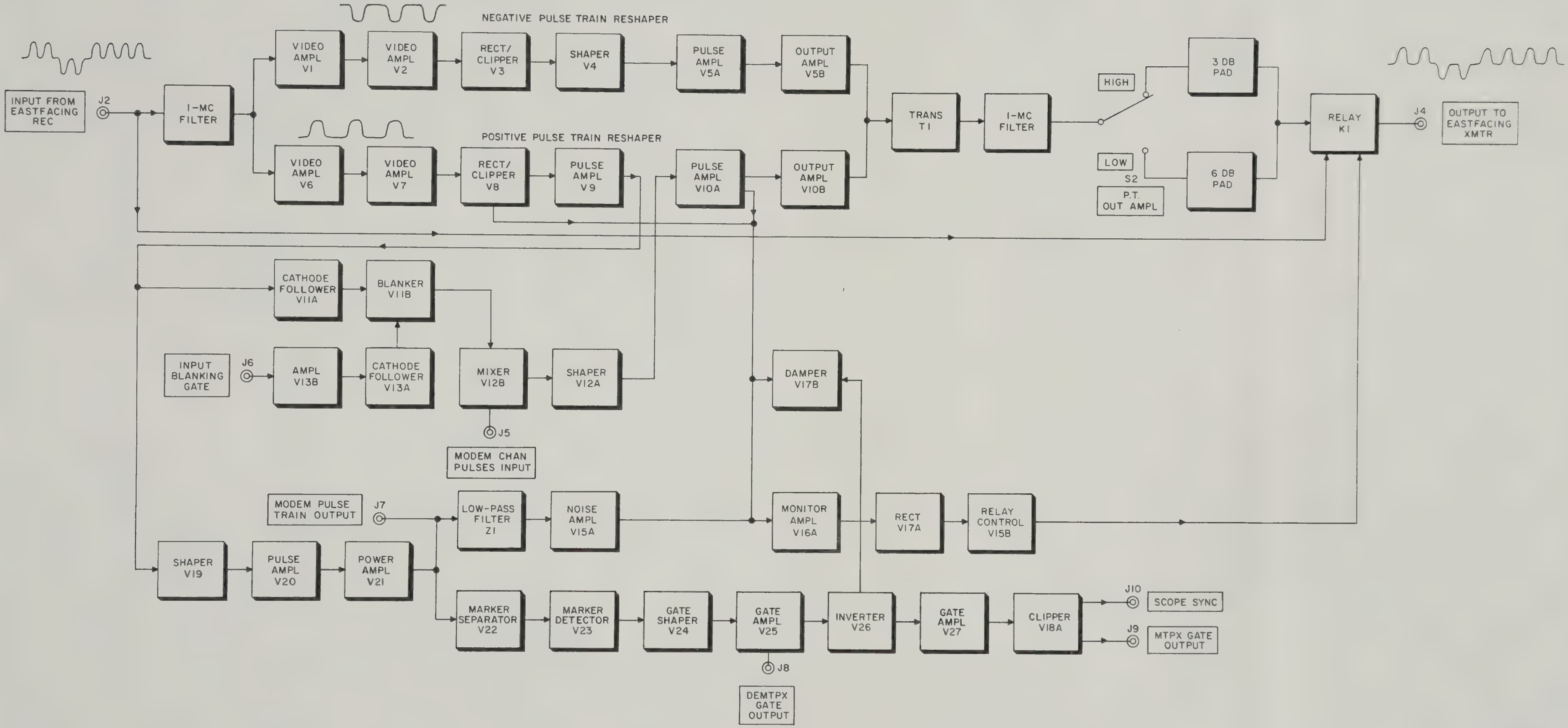
(3) A 20-cycle ringing supply.

d. Oscilloscope OS–25/G (fig. 110). This unit is a 5-mc bandwidth oscilloscope that meets the requirements for the maintenance and alignment of the various sections of the multiplexer group. It differs from the ordinary test oscilloscope because it includes a continuously variable phase synchronizing circuit and 5.2-microsecond timing pips for the alignment of the unmodulated channel pulses. In addition, it may be used as a high quality, general purpose, wide-band oscilloscope for trouble shooting. The oscilloscope (par. 137) consists of a vertical deflection amplifier, timing mark generator, horizontal sweep, cathode-ray tube, and power supply circuits. The vertical deflection and calibration circuits amplify the input signal and tap off a 60-cycle signal for a voltage calibration by comparison. The horizontal sweep provides horizontal deflection for the cathode-ray tube. A timing mark generator provides calibrated crt time signals. Power supplies for all circuits are also included.

Section II. THEORY OF VIDEO RESTORER

119. General

a. Before making a detailed discussion of the circuitry involved, refer to the video restorer block diagram (fig. 111) and the over-all schematic diagram (fig. 260). Note that the block diagram is divided into sections, each of which performs one or more of the desired functions. Stages V1 through V5B provide reshaping of the negative part of the pulse train if the input is a 45-channel composite pulse train. Stages V6 through V10 provide reshaping of the positive part of the pulse train. As shown in the block diagram, the composite signal appears at the input, and the negative and positive components are separated and reshaped in their respective reshaper sections. Transformer T1 provides mixing of the two reshaped pulse trains to re-form the 45-channel composite as shown at the output, and it also provides matching of the two pulse output tubes, V5B and V10B, to the 50-ohm output load. Stage V11 provides blanking of one to eight channels from the positive pulse train; stage V12 provides for shaping of the channel pulses generated in the local modems and mixes them with the pulse train that has had channels blanked from it. Stage V13 provides a low source impedance from which to drive the shaped blanking gates into stage V11 for


NEGATIVE PULSE TRAIN RESHAPER
POSITIVE PULSE TRAIN RESHAPER
INPUT FROM EASTFACING REC
J2
I-MC FILTER
VIDEO AMPL V1
VIDEO AMPL V2
RECT/ CLIPPER V3
SHAPER V4
PULSE AMPL V5A
OUTPUT AMPL V5B
VIDEO AMPL V6
VIDEO AMPL V7
RECT/ CLIPPER V8
PULSE AMPL V9
PULSE AMPL V10A
OUTPUT AMPL V10B
TRANS T1
I-MC FILTER
HIGH
LOW
S2
P.T. OUT AMPL
3 DB PAD
6 DB PAD
RELAY K1
J4
OUTPUT TO EASTFACING XMTR
CATHODE FOLLOWER V11A
BLANKER V11B
INPUT BLANKING GATE
J6
AMPL V13B
CATHODE FOLLOWER V13A
MIXER V12B
SHAPER V12A
J5
MODEM CHAN PULSES INPUT
DAMPER V17B
MODEM PULSE TRAIN OUTPUT
J7
LOW-PASS FILTER Z1
NOISE AMPL V15A
MONITOR AMPL V16A
RECT V17A
RELAY CONTROL V15B
SHAPER V19
PULSE AMPL V20
POWER AMPL V21
MARKER SEPARATOR V22
MARKER DETECTOR V23
GATE SHAPER V24
GATE AMPL V25
INVERTER V26
GATE AMPL V27
CLIPPER V18A
J10
SCOPE SYNC
J9
MTPX GATE OUTPUT
J8
DEMTPX GATE OUTPUT

TM5091-605

Figure 111. Video restorer, over-all block diagram.

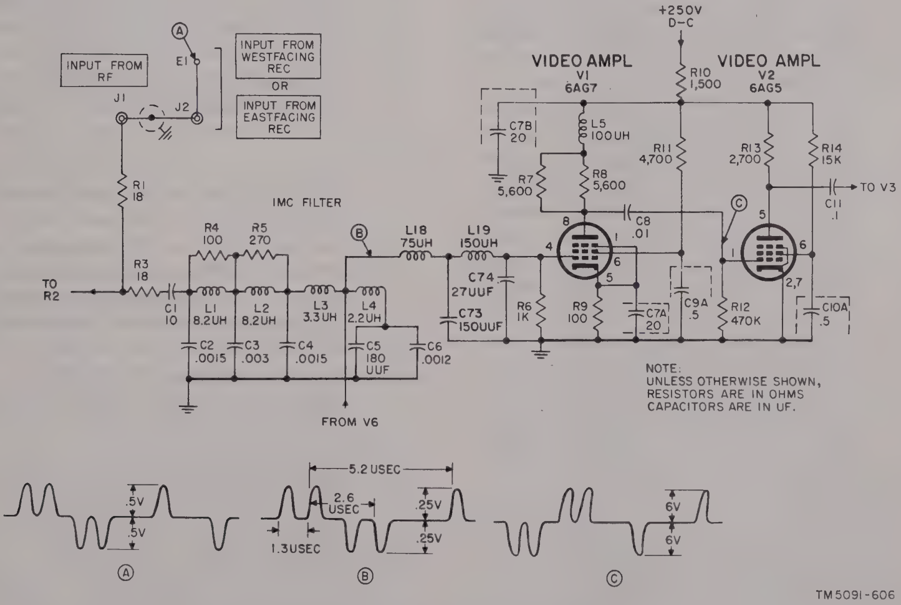
blanking. Stages V15 through V18B provide detectors for various alarm and ringing disconnect conditions. Stage V14 provides a low impedance source of 75 volts dc for the signaling circuits in the modems. Stages V19 through V21 provide the negative 35-volt pulse train required for demodulation in the modems. Stages V22 through V25 provide a negative gate to drive the demodulator delay line for selection of the channel pulses in the modems, and stages V26 and V27 provide for generation of a positive gate to drive the modulator delay line for generating channel pulses in the modems. A diode (V18A) and a VR tube (V28) provide for clipping of this gate at ±105 volts while 8-kc synchronizing voltage for the oscilloscope is derived from this gate by the tuned circuit that consists of L17 and C71.

b. The input wave train passes through a 1-megacycle filter. This is used to remove the 6-megacycle component of the signal that otherwise results in undesirable cross talk. The filter is a high cutoff type; that is, all frequencies above 1 megacycle are attenuated.

120. Negative Reshaping Circuit

a. General. The negative reshaping circuit consists of video amplifiers V1 and V2, rectifier clipper V3, shaper V4, pulse amplifier V5A, and output amplifier V5B. The output of the 1-mc filter is applied to the negative pulse train reshaper. With the 23 CHAN-45 CHAN switch in the 45 CHAN position, filament voltage is applied to the negative reshaping stage. If the switch is in the 23 CHAN position stage, V1 through V5 are inoperative.

b. Video Amplifier V1 (fig. 112). The output of the 1-mc filter is applied to a delay network, L18, L19, C73, and C74, and is developed across grid return resistor R6. The delay network has been added to compensate for the slight difference in phase delay between the positive and negative pulse train reshaper. The positive pulse train reshaper has a nominal delay of .22 microsecond more than the negative because of the additional stages of amplification. Without this delay network the effect on long systems would accumulate in phase to the extent that eventually the two markers would coalesce and marker separation would



INPUT FROM RF
Ⓐ
E1
J1
J2
INPUT FROM WESTFACING REC
OR
INPUT FROM EASTFACING REC
R1 18
R3 18
TO R2
C1 10
1MC FILTER
R4 100
R5 270
L1 8.2UH
L2 8.2UH
L3 3.3UH
L4 2.2UH
C2 .0015
C3 .003
C4 .0015
C5 180 UUF
C6 .0012
FROM V6
Ⓑ
L18 75UH
L19 150UH
C74 27UUF
C73 150UUF
R6 1K
+250V D-C
VIDEO AMPL V1 6AG7
VIDEO AMPL V2 6AG5
C7B 20
L5 100UH
R7 5,600
R8 5,600
R10 1,500
R11 4,700
R13 2,700
R14 15K
C8 .01
R9 100
C7A 20
C9A .5
R12 470K
C10A .5
C11 .1
TO V3
Ⓒ
NOTE: UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS CAPACITORS ARE IN UF.
.5V
.5V
5.2 USEC
2.6 USEC
1.3USEC
.25V
.25V
6V
6V
Ⓐ
Ⓑ
Ⓒ
TM5091-606

Figure 112. Video amplifiers V1 and V2.

be impossible. The positive and negative pulses are applied to the grid of V1 and are amplified. The output voltage, developed across resistor R7 and R8 in series with shunt peaking coil L5, is coupled to the grid of V2 by coupling capacitor C8. Peaking coil L5 is placed in the circuit as part of the plate load to compensate for the loss that would normally occur at higher frequencies. Screen voltage is supplied by screen voltage dropping resistor R11. The screen is kept at an r-f ground potential by capacitor C9A; plate voltage is applied through the plate decoupling network R10 and C7B. Cathode bias is developed across R9 and C7A.

c. Video Amplifier V2.

(1) The second video amplifier, V2, is operated as a grid-leak type limiter. The 45-channel pulse train applied to the grid of V2 from the plate of V1 will contain both negative and positive pulses (B, fig. 112). This stage suppresses the negative pulses and amplifies the positive pulses.

(2) When no signal is applied to the grid, the tube will conduct heavily. A grid-leak combination, which consists of C8 and R12, is placed in the input circuit of the tube. Positive peaks from the incoming signal drive the grid positive, causing the grid to draw current. This current charges capacitor C8. During the negative portion of the input signal, the grid no longer draws current. This allows capacitor C8 to discharge through grid-leak resistor R12, developing the negative operating bias of the tube. Because of this bias, the incoming positive pulses will be amplified while the negative pulses will drive the tube beyond cutoff, suppressing the peaks of the negative pulses. In this manner, the output voltage developed across R13 consists of large negative pulses and small positive pulses (A, fig. 113).

(3) Capacitor C11 is the output coupling capacitor that feeds the output of V2 to rectifier-clipper V3. Resistor R14 is the screen dropping resistor. Capacitor C10A is the screen bypass capacitor.

d. Rectifier-clipper V3 and Shaper V4 (fig. 113).

(1) Rectifier-clipper tube V3 is arranged so that one-half of it rectifies the negative peak of the pulse train supplied to it. About 40 per cent of this rectified voltage is developed across resistor R17 and is used to bias the lower diode so that it will not conduct until the negative pulse train reaches 40 per cent of its final value. In this manner, the lower limit on the slice taken out of the pulse train is set at 40 per cent. Since the second stage uses grid-leak bias, some of the pulse train in the vicinity of the base line will be clipped when the input to the entire circuit is greater than .6 volt; therefore, the lower clipping level will be somewhat larger than 40 per cent of the original pulse when the input exceeds this amount.

(2) Resistor R15 is the cathode resistor for both sections of V3. Resistor R16 in series with R17 forms a voltage divider network in the plate circuit of the rectifier section of V3 and is bypassed by capacitor C12A. Resistor R17 is the plate biasing resistor of the other section. The output signal voltage is coupled to the grid of shaper V4 by coupling capacitor C13.

(3) The 10-volt negative output of diode clipper V3 is fed to the grid of V4 (B, fig. 113). In shaper stage V4, all the pulses in the train are narrowed to about ¼ microsecond by the action of ringing coil L6 (C, fig.113). The germanium diodes, CR1 and CR2, clip the top and bottom of this pulse train to improve the waveshape. Resistor R21 damps the ringing. In addition, CR2 overdamps the shock-excited oscillations after the first half-cycle (note the damping effect on the second half-oscillation cycle in D, figure 113). The grid of V4 is returned to B+ through resistor R18. Resistor R19 and capacitor C14 form the plate power supply decoupling network. The plate is further de-

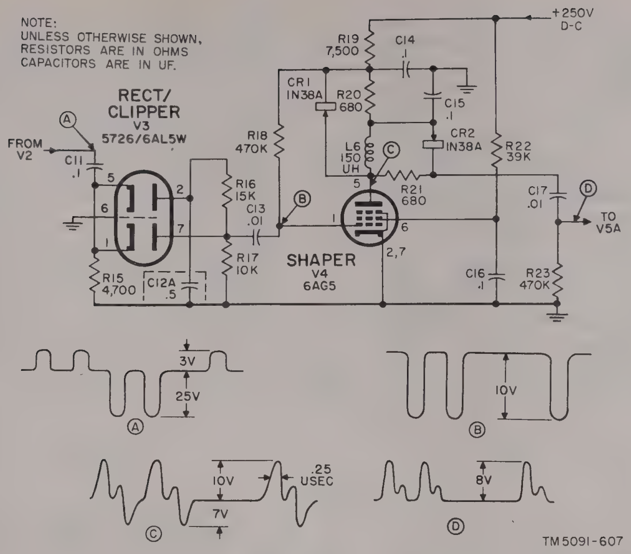

NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
RECT/
CLIPPER
V3
5726/6AL5W
FROM
V2
C11
.1
R15
4,700
C12A
.5
R16
15K
C13
.01
R17
10K
R18
470K
CR1
IN38A
R19
7,500
R20
680
C14
.1
C15
.1
CR2
IN38A
L6
150
UH
R21
680
SHAPER
V4
6AG5
2,7
+250V
D-C
R22
39K
C16
.1
C17
.01
R23
470K
TO
V5A
3V
25V
10V
10V
7V
.25
USEC
8V
A
B
C
D
TM5091-607

Figure 113. Rectifier-clipper V3 and shaper V4.

coupled by R20 and C15. Resistor R22 is the screen resistor and is bypassed by C16. The grid of V4 is returned through R18 to B+. This positive bias causes the tube to conduct and clip the positive pulses that appear on the grid. Capacitor C17 is the output coupling capacitor to V5.

e. Pulse Amplifier V5A and Output Amplifier V5B (fig. 114).

(1) The wave form at the output of V4 (D, fig. 113) is applied to the grid of V5A and is amplified. The grid of pulse amplifier V5A is returned to ground through R23. Resistor R24 is the plate load. Plate decoupling is provided by R26 and C20A. The cathode is biased by resistor R25 which with R26 and R27 forms a voltage divider network in the B+ circuit to get a proper positive voltage on the cathode in order to bias the tube negatively. Capacitor C18 is the cathode-bypass capacitor. The signal developed in the plate circuit of V5A is coupled to the grid of V5B through capacitor C19. The output of V5A is fed to the junction of resistors R28 and R29. The signal as it appears on the grid of V5B is shown in A, figure 114, after amplification by V5A, and grid clipping in V5B. The grid of V5B is not returned to the cathode but through a high resistance (R29 and R28) to the plate voltage supply. With this arrangement the grid to cathode voltage is maintained at a value close to zero. When the grid is made positive with respect to the cathode, grid current will effectively reduce the grid-to-cathode internal resistance. The voltage drop across the internal resistance will be very small. When the input voltage drives the grid positive, the grid presents a very low resistance. Therefore, the input voltage is very low and results in very little change in plate current. However, if a negative voltage is applied to the grid, the grid resistance will increase, causing the full input voltage to appear between grid and cathode and consequently a large change in plate current. The result is to clip the positive pulses and produce the waveshape shown at B, figure 114. A similar waveshape from the positive

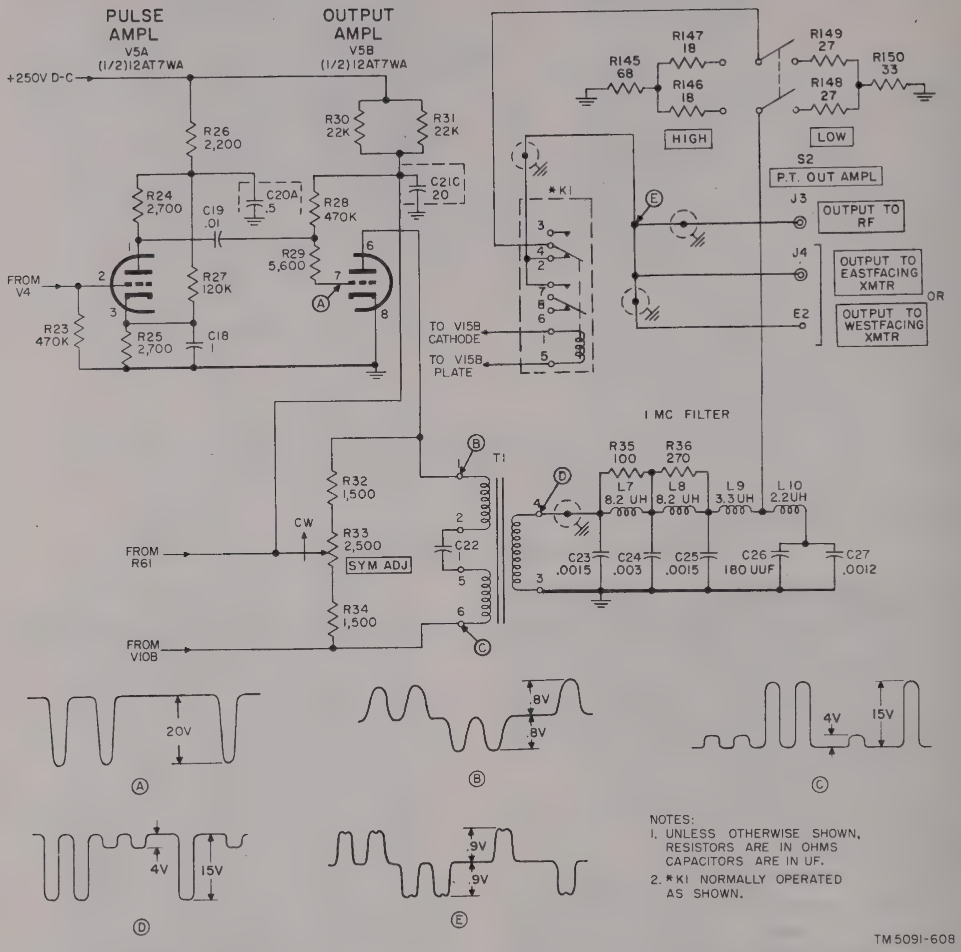

PULSE AMPL
V5A
(1/2)12AT7WA
OUTPUT AMPL
V5B
(1/2)12AT7WA
+250V D-C
R26 2,200
R24 2,700
C19 .01
C20A .5
R28 470K
R30 22K
R31 22K
C21C 20
R29 5,600
FROM V4
R23 470K
R27 120K
R25 2,700
C18 1
TO V15B CATHODE
TO V15B PLATE
*K1
R145 68
R147 18
R146 18
HIGH
R149 27
R148 27
R150 33
LOW
S2
P.T. OUT AMPL
J3
OUTPUT TO RF
J4
OUTPUT TO EASTFACING XMTR
OR
E2
OUTPUT TO WESTFACING XMTR
1 MC FILTER
R35 100
R36 270
L7 8.2 UH
L8 8.2 UH
L9 3.3 UH
L10 2.2UH
C23 .0015
C24 .003
C25 .0015
C26 180 UUF
C27 .0012
T1
C22
R32 1,500
CW
R33 2,500
SYM ADJ
R34 1,500
FROM R61
FROM V10B
20V
.8V
.8V
4V
15V
4V
15V
.9V
.9V
A
B
C
D
E
NOTES:
1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS CAPACITORS ARE IN UF.
2. *K1 NORMALLY OPERATED AS SHOWN.
TM 5091-608

Figure 114. Pulse amplifier V5A and output amplifier V5B.

reshaper appears at C. It is then mixed in transformer T1 and appears in the output, as shown in E, figure 114. After going through the 1-mc filter, it appears as shown in E, figure 114.

(2) For V5B, R30 and R31 with C21C provide decoupling. Resistor R28 is the grid return to B+. Resistor R29 is in series with the grid to produce clipping. SYM ADJ R33 is included to allow balancing of the positive and negative portions of the output waveshape. Transformer T1 mixes the outputs and couples it to the line.

(3) By placing a capacitor (C22) in series with the two primary windings of transformer T1, no dc flows in the primary. This eliminates the inductance usually caused by the d-c current in the primary which would cause poor low-frequency response. The inverted reshaped pulse train is fed to a 1-megacycle low-pass filter to re-

establish the standard waveshape. The output of the filter is fed to the output jack, J4, through a T-pad network and through contacts on the bypass relay K1. This relay is so arranged that in event of failure of the equipment it will bypass the input signal to the output; otherwise it connects the output jacks to the output of the reshaper. P.T. OUT AMPL switch S2 connects either R146, R147, and R145 (HIGH) or R148, R149, and R150 (LOW) T pad into the circuit. When placed in the LOW position, a 12-db pad is inserted across the output. When placed in the HIGH position, a 6-db pad is inserted across the output. The output pulse train is nominally .9 volt peak when fed to a 50-ohm load and nominally 1.8 volts peak open circuit. This, therefore, meets the requirements of at least .7-volt peak output and 50-ohm output impedance. The output waveshape (E, fig. 114) is therefore similar but reshaped to the input (A, fig. 112).

f. 1-mc Output Filter. In frequency-modulated systems, bandwidth must be limited by filtering the output. This is done by the filter system consisting of L7, L8, L9, L10, R35, R36, C23, C24, C25, C26, and C27 (fig. 259). The filter has a nominal cutoff frequency of 1 mc and is down 30 db at 3 mc. The input is fed in from transformer T1, while the output is fed to the P.T. OUT AMPL switch.

121. Positive Reshaping Circuit

a. The positive pulse train reshaper circuit consists of tubes V6 through V10 (fig. 111 and 260). Note that the circuit is essentially the same as the negative pulse train reshaper described in paragraph 120. The input stage, V6, is operated as a grounded grid amplifier and is fed in parallel with V1. There is no phase inversion in the first stage; hence the wave form polarities following this stage are identical to those in the negative pulse train reshaper. Resistor R37 is the grid return to ground. Resistors R38 and R39 in parallel are the plate load; R40 is the cathode return. Decoupling is provided by R41 and C7C. Resistor R42 is the screen resistor and is bypassed by C9B. The output coupling capacitor is C28.

b. Tube V7 is identical in operation to V2 (fig. 112). Resistor R43 is the grid return, R44 is the plate resistor, R45 is the screen resistor, C10B is the screen bypass capacitor, and C29 is the output coupling capacitor.

c. Tube V8 is identical to tube V3 (fig. 113). Resistor R46 is the cathode resistor; R47 and R48, in series, are the plate load of one section; R48 is the plate load of the other. The first plate is bypassed by C12B. The output coupling capacitor is C31.

d. Tube V9 is a shunt peaked voltage amplifier and a counterpart in the negative pulse train reshaper, V4 (fig. 113). The output of V9 is a positive pulse train and is fed to the blank and insert stages, which consist of V11 and V12. Resistor R50 and capacitor C30 are the decoupling network; resistor R49, the grid return; resistor R51 and inductor L12, the plate load; and resistors R52 and R53, the screen divider. The screen is bypassed by C32. The output is coupled by C33.

e. The pulse shaping that narrows all pulses in the train to about ¼ microsecond is done in the plate of V12A (fig. 125). The output of this tube is then fed to V10A, a twin triode amplifier like V5 (fig. 114), in the negative pulse train reshaper. The output of V10B is then supplied to the second primary of the output coupling transformer, T1. The secondary of the transformer then feeds the reformed 45-channel composite pulse train to a 1-megacycle low-pass filter. The plate load resistances of the two output tubes, V5 and V10, contain a common 2,500-ohm potentiometer, R33, the movable arm of which is returned to the B+ supply. This potentiometer (SYM ADJ) provides a symmetry control with which to adjust the positive and negative pulse trains in the composite to equal peak amplitudes. Resistors R32 and R34 are the plate-to-plate resistance. Capacitor C34 is the input coupling capacitor to V10A. Resistor R54 is the grid return; R55, the plate load; R58 and C20B, the decoupling combination; R56 and R59 form a divider for cathode bias;

and C35 is the cathode bypass. Capacitor C36 is the input coupling to V10B, R62 is a series grid resistor (as in the tube V5B), and R61 is the grid return.

122. Demultiplexing and Demodulating Circuit (Waveshapes Supplied to Modems for Demodulation)

(fig. 115)

a. General. The demultiplexing and demodulating circuit accepts the pulse train and produces a negative pulse from which operates the demodulator as explained in paragraph 125.

b. Shaper V19. The entire positive pulse train is taken from pulse amplifier V9 and fed to the grid of V19, which is a shaper stage similar to V4. That is, all of the pulses in the train are narrowed to about ¼ microsecond by shock excitation of L14 and then by overdamping by CR7 after the first half-cycle. (Review shaper stage V4 (par. 120*d*(3) for explanation of shock excited .25-microsecond pulses.) The plate of V19 is decoupled from the B+ supply by L15 and C50B. This decoupling circuit also prevents self-sustained oscillations for the entire section consisting of tubes V19 through V27. For shaper tube V19, resistor R98 is the grid return and R99 is a parasitic suppressor. Coil L15 with resistors R103, R102, and R100 form a voltage divider network supplying the correct screen grid and cathode voltage. Capacitor C55A is the screen grid bypass capacitor. Cathode resistor R100 is part of the voltage divider and provides proper fixed bias voltage. Capacitor C54A is the cathode bypass capacitor. Resistor R101 is a limiting resistor. Capacitor C56 couples the output of V19 to the grid of pulse amplifier V20.

c. Pulse Amplifier V20. The output of the shaper that consists of negative pulses (B, fig. 115) is fed to the grid of pulse amplifier V20 through capacitor C56. The grid of pulse amplifier V20 is returned to the B+ supply through a 1-megohm resistor R104 to cause the grid to clip any remaining positive overshoot. (Refer to paragraph 120*e*(1) for explanation of grid limiting when the grid is connected to B+.) A normal grid signal of approximately 18 volts is more than sufficient to drive this tube to cutoff giving a square output pulse. Resistor R105 is a grid series resistor to aid clipping; R106, R107, and R108 in series are the plate load, R109 and R110 in series are the screen grid voltage dropping resistors. The screen is bypassed by C55B.

d. Power Amplifier V21. The output of pulse amplifier V20 is fed to power amplifier V21 through coupling capacitor C57. The output of V21, a 35-volt negative pulse train, is applied to the grid of V22 and to J7 (A, fig. 116). This

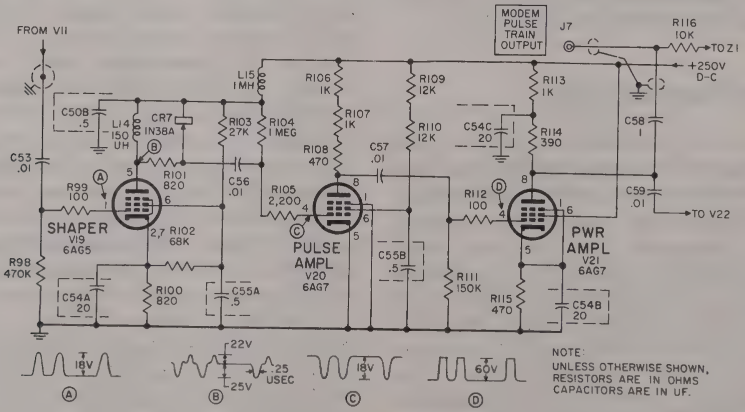

FROM V11
C50B .5
L14 150 UH
CR7 IN38A
C53 .01
R99 100
Ⓐ
Ⓑ
R101 820
5
1
6
SHAPER
V19
6AG5
2,7 R102 68K
R98 470K
C54A 20
R100 820
C55A .5
R103 27K
R104 1 MEG
L15 1MH
C56 .01
R105 2,200
4
Ⓒ
PULSE AMPL
V20
6AG7
R106 1K
R107 1K
R108 470
C57 .01
8
1
6
5
C55B .5
R109 12K
R110 12K
R111 150K
MODEM PULSE TRAIN OUTPUT
J7
R116 10K
TO Z1
+250V D-C
R113 1K
C54C 20
R114 390
C58 1
R112 100
Ⓓ
8
4
1
6
5
PWR AMPL
V21
6AG7
R115 470
C54B 20
C59 .01
TO V22
18V
Ⓐ
22V
25V
.25 USEC
Ⓑ
18V
Ⓒ
60V
Ⓓ
NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
TM5091-609

Figure 115. Circuits for modem demodulation waveshapes.

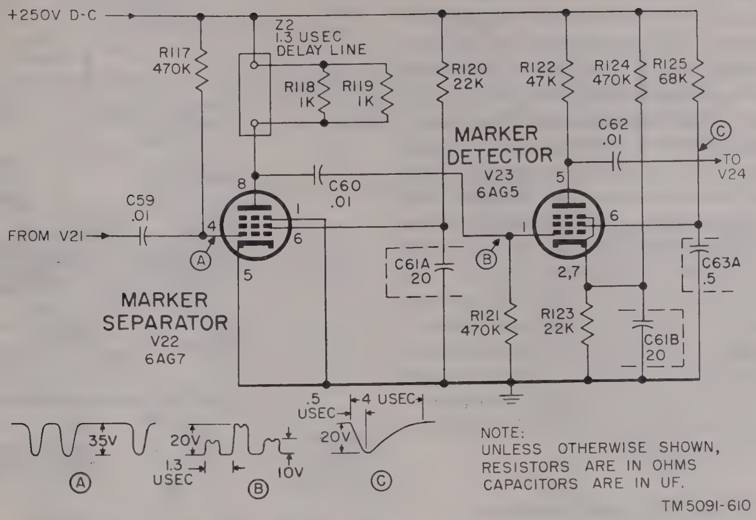

+250V D-C
Z2
1.3 USEC
DELAY LINE
R117
470K
R118
1K
R119
1K
R120
22K
R122
47K
R124
470K
R125
68K
C62
.01
Ⓒ
TO
V24
MARKER
DETECTOR
V23
6AG5
5
8
C60
.01
C59
.01
FROM V21
4
1
6
Ⓐ
5
C61A
20
Ⓑ
1
6
2,7
C63A
.5
R121
470K
R123
22K
C61B
20
MARKER
SEPARATOR
V22
6AG7
.5
USEC
4 USEC
35V
20V
1.3
USEC
10V
20V
Ⓐ
Ⓑ
Ⓒ
NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
TM5091-610

Figure 116. Marker separator V22 and marker detector V23.

pulse train is used to supply the demodulators in the modems as explained in paragraph 125. Power amplifier V21 is a 6AG7 pentode. The 6AG7 pentode can be used in this circuit since it need supply only a maximum of eight modems. Resistor R111 is the grid return, R112 is a grid harmonic suppressor, R113 and C54C provide the plate decoupling network, R114 is the plate load, and R115 is the cathode bias resistor, bypassed by C54B. Capacitor C58 is the output coupling capacitor that feeds the output to J7, and C59 couples the output to marker separator tube V22.

123. Marker Separator V22 and Detector Stage V23

(fig. 116)

a. General. The negative gate that must be supplied to the demodulator delay line is formed from the pulse train at the output of power amplifier V21 by the stages that consist of marker separator V22 through gate amplifier V25.

b. Marker Separator V22. Marker separator V22 has a 500-ohm, .65-microsecond, open-circuited delay line, Z2, as its plate load. The input to this delay line consists of the entire pulse train that appears on the grid of V22 (inverted) (A, fig. 116) plus the entire pulse train, which is reflected from the open-circuited delay line. Since Z2 is a .65-microsecond, open-circuited delay line, this reflected pulse train appears 1.3 microseconds later than the input pulse train (.65 +.65=1.3) and is absorbed by the 500-ohm input termination that consists of R118 and R119, so that no further reflections occur. Since the spacing of the two pulses in the marker is 1.3 microseconds, a double amplitude pulse appears at the time of the second pulse at the plate of V22 (B, fig. 116). Resistor R117 is the grid return, C60 is the output coupling capacitor, and R120 is the screen resistor, bypassed by C61A.

c. Marker Detector V23. The output of the marker separator (B, fig. 116) is then fed to marker detector V23 through coupling capacitor C60. The marker detector is operated considerably below cutoff so that only the more positive double amplitude pulses from the marker separator will cause it to conduct. The a-c plate load of V23 consists essentially of plate resistor R122 and L16 in the grid circuit of gate shaper V24. When the driving pulse disappears, the shunt capacitance of the coil discharges through the coil. This causes the circuit to become oscillatory but the overshoots are clipped by the grid of gate shaper V24. Thus, the wave form at the grid of waveshaper V24 is a negative triangle as shown at C, figure 116. The leading edge of this wave form lasts for the duration of the driving pulse on the grid of V23 (about .5 microsecond), and the length of the trailing edge is determined by the rate of discharge of the shunt capacitance of L16. The width of this wave form near the base line is about 4 microseconds, and its amplitude is more than sufficient to cut off gate shaper V24. Resistor R121 is the grid return of tube V23, R122 is the plate resistor, C62 is the output coupling capacitor, R123 is the cathode resistor, which is bypassed by C61B. Resistor R124, in series with R123, is a voltage divider to put fixed bias on the cathode, R125 is the screen grid voltage dropping resistor, and C63A is the screen grid bypass capacitor.

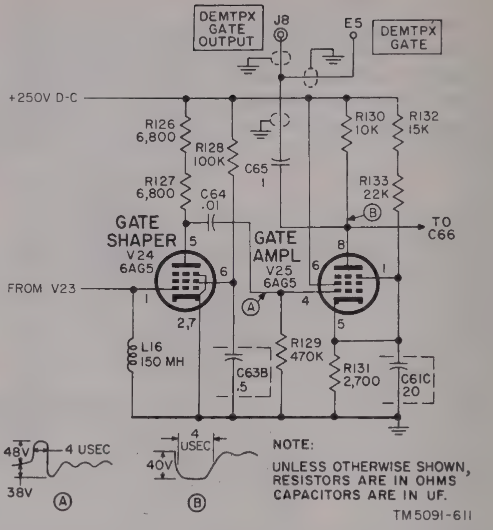


Figure 117. Gate shaper V24 and amplifier stage V25.

124. Gate Shaper V24 and Amplifier Stage V25

(fig. 117)

a. The output waveshape is applied to choke L16 and appears at the plate of gate shaper V24 as the wave form (A, fig. 117). However, since gate amplifier V25 is biased below cutoff, the base line is lost at the plate of gate amplifier V25 and only the waveshape shown at B, figure 117, appears. Resistors R126 and R127 are in series and form the plate load resistor, R128 is the screen resistor, C63B is the screen bypass, and C64 is the output coupling capacitor.

b. The output of gate amplifier V25 is a negative rectangular voltage of about 4-microsecond width and 130-volt amplitude when fed to a 3,000-ohm load at J8. This 4-microsecond 130-volt negative pulse is the required wave form to be fed to the demodulator delay line. Resistor R129 is the grid return; R130 is the plate load; R131, R132, and R133 are a divider to give cathode bias; C61C is the cathode bypass; and C65 couples the output to DEMTPX GATE output jack J8 and DEMTPX GATE test point E5.

125. Modem Demodulator Circuit

a. General (fig. 118). The modem demodulator (par. 111) operates to convert a ppm signal to a pwm signal, which contains the audio component and only needs to be filtered to give the audio output.

b. Block Diagram. Video restorer gate amplifier V25 provides the pulse for the delay line. The delay line sawtooth is applied to a gate generator (V3A). This produces a gate for operating the demodulator. The gate determines the time during which the demodulator accepts signals (par. 112*c*). The input pulse train developed at the output of video restorer power amplifier V21 is also fed to the demodulator pwm converter (V3B). During the gate time, conversion to pwm takes place. The pwm signal is applied to the clipper amplifier (V4A) and then is applied to the low-pass filter, which extracts the audio signal. The audio output is amplified by the audio output stage (V4B), and the output of V4B is fed to the output TEST PAIR terminals.

c. Stage Analysis.

(1) *Modem gate generator V3A and pwm converter V3B* (fig. 119).

(*a*) The negative sawtooth from the delay line is applied to the grid of tube V3A in the modem demodulator.

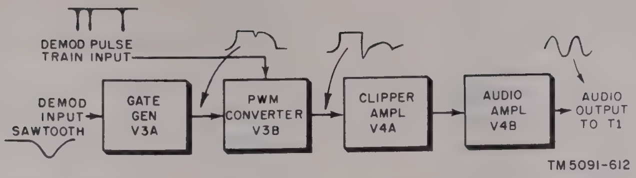


Figure 118. Modem demodulator section.

These negative sawtooth waves cut off plate current, producing positive gates in the plate circuit. A voltage pulse appears on the plate. This is fed back from the following stage. The cathode of crystal diode CR4 is about 30 volts positive with respect to the quiescent plate voltage established by the current flowing through resistor R21 and filtered by capacitor C11. Diode CR4 conducts at about 30 volts. This conducts and clips the top of the first positive half-cycle, giving a flat top pulse as shown by the 28-volt wave form at the plate of V3A in figure 119. The succeeding negative cycle is damped by the action of the current flowing through diode CR5 in series with limiting resistor R23. Thus, a 28-volt pulse is generated by this stage, corresponding in time to the negative sawtooth applied to the grid of gate generator V3A. This is the time allocated to this channel by the demultiplexer delay line. The gate starts when the sawtooth voltage applied to the grid takes the tube beyond cutoff.

(*b*) Resistor R19 is the grid return and R20 is a grid limiter. The tube is normally at zero bias and conducting. Resistor R22 is the plate decoupling resistor and C7 is the plate decoupling capacitor. Resistor R20 limits grid current during signal flow.

(*c*) Pwm converter tube V3B is normally held at cutoff by the negative fixed bias which results from the large potential (approximately 47 to 52 volts) applied to its cathode through the voltage divider, which consists of R25, R28, and R42. The pulse train is fed to the cathode of V3B through capacitor C8. Taken individually, neither the gate applied to the grid (28 volts) nor the channel pulse (35 volts) decreases the positive cathode potential enough to cause plate current to flow. When these two occur together, as they do only when the gated channel pulse occurs, plate current flows in tube V3B.

(*d*) Part of the 28-volt pulse generated by the inductive differentiator plate circuit of gate generator tube V3A is coupled to the plate of pwm converter tube V3B through a parallel combination of resistor R24 and C9 in series with C12. Thus, V3B plate voltage contains a positive gate starting at the time the unblocking sawtooth is applied to the demodulator. The coincidence of the gate on the grid and the channel pulse on the cathode of tube V3B results in a large current flow through plate load resistor R29, making the plate more negative only at the time the channel pulse occurs. The negative swing does not recover until the gate ends; consequently, a pulse-width-modulated signal is generated which starts at the time the unblocking pulse appears, and ends at the time the position-modulated channel pulse appears and causes the tube to draw current. This is the process of time demultiplexing which selects the appropriate channel to be detected in each stage. In

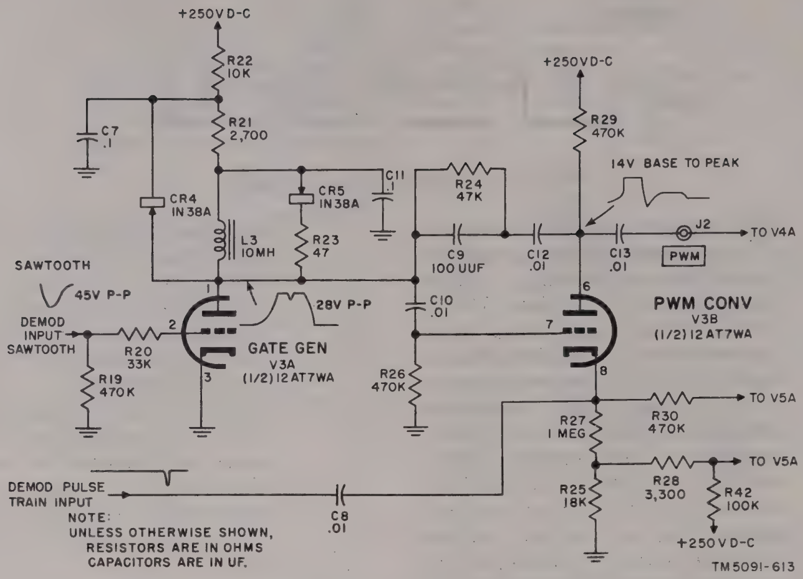

+250V D-C
R22
10K
R21
2,700
C7
.1
CR4
IN38A
CR5
IN38A
C11
.1
L3
10MH
R23
47
R24
47K
+250V D-C
R29
470K
14V BASE TO PEAK
J2
TO V4A
PWM
C9
100 UUF
C12
.01
C13
.01
SAWTOOTH
45V P-P
28V P-P
C10
.01
PWM CONV
V3B
(1/2) 12AT7WA
DEMOD
INPUT
SAWTOOTH
R20
33K
GATE GEN
V3A
(1/2) 12AT7WA
R19
470K
R26
470K
TO V5A
R27
1 MEG
R30
470K
TO V5A
DEMOD PULSE
TRAIN INPUT
C8
.01
R25
18K
R28
3,300
R42
100K
+250V D-C
NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
TM5091-613

Figure 119. Demodulator gate generator V3A and pwm converter V3B.

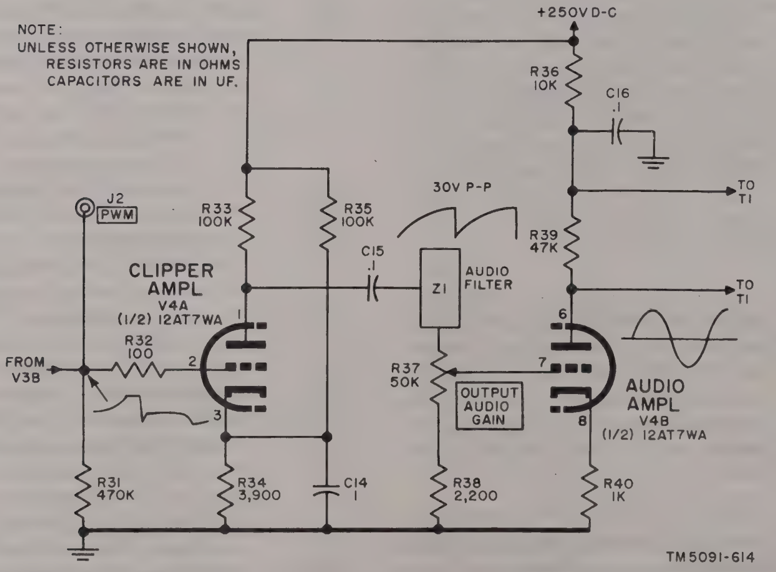

NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
+250V D-C
R36
10K
C16
.1
TO
T1
J2
PWM
R33
100K
R35
100K
30V P-P
R39
47K
C15
.1
CLIPPER
AMPL
V4A
(1/2) 12AT7WA
Z1
AUDIO
FILTER
TO
T1
R32
100
FROM
V3B
R37
50K
OUTPUT
AUDIO
GAIN
AUDIO
AMPL
V4B
(1/2) 12AT7WA
R31
470K
R34
3,900
C14
1
R38
2,200
R40
1K
TM5091-614

Figure 120. Demodulator clipper and audio amplifier, stages V4A and V4B.

other words, one pulse appearing on the plate and grid is mixed with another appearing on the cathode.

(*e*) Resistor R26 is the grid return, capacitor C10 is the input coupling capacitor, and C13 is the output coupling capacitor. R30 is a dropping resistor, and R27 acts as a voltage divider with R25.

(2) *Clipper and audio amplifier stages V4A and V4B* (fig. 120).

(*a*) The positive pwm signal generated at the plate of pulse-width modulator tube V3B has a fixed leading edge in time; that is, it is fixed with respect to the received marker pulse. It has a trailing edge that is time-modulated since it is derived from the ppm pulse. This signal is applied to the clipper-amplifier tube V4A, through resistor R32, a grid parasitic suppressor. Clipper-amplifier tube V4A is biased below cutoff by returning the cathode to B+ through resistor R35. This stage will accept only the top of the signal that drives the tube out of cutoff (true pwm). The amplified output is impressed across the plate load resistor R33. The low-pass audio filter Z1 removes all but the audio portion of the signal and through its tank circuit effect produces a sinusoidal wave. The 30-volt audio output signal as shown in figure 120 is impressed on the grid of audio amplifier V4B. The output signal applied to OUTPUT AUDIO GAIN control R37 in series with resistor R38 will be the duplicate of the a-f signal that modulates the channel pulse at the transmitter end. The cathode of V4A gets bias through the divider network R34 and R35. Capacitor C14 acts as the cathode bypass capacitor.

(*b*) Potentiometer R37 is an audio gain control regulating the signal input to amplifier tube V4B. The plate load of V4B consists of one winding of hybrid transformer T1 in parallel with resistor R39, which provides the correct output impedance for the transformer. Resistor R38 completes the grid return circuit and is inserted in series with potentiometer R37 so that the arm of the potentiometer can never be turned so low that no output is obtained from this channel. Resistor R40 provides cathode bias. The omission of a cathode bypass capacitor introduces a degenerative bias, improving the fidelity of V4B. Capacitor C16 is the plate decoupling capacitor and R36 is the plate decoupling resistor. Hybrid transformer T1 provides for the audio output to be connected to either a two-wire or four-wire local line.

(3) *Ringing amplifier V5* (fig. 121). Ringing amplifier tube V5 is a d-c amplifier used to control alarm ringing relay K2. When the system is operating normally, d-c amplier V5A is conducting heavily and ringing relay control tube V5B is held at cutoff by having its cathode returned to a +75-volt d-c source. The grid of V5B is connected directly to the plate of V5A, and its plate is connected through R44, a limiting resistor, to the relay coil and then to B+. The demodulator pulse train input is applied to the grid of V5A through R30. Therefore, tube V5A is kept conducting, and its plate voltage low. The grid voltage of tube V5B is also low. When the demodulator pulse train input is not present, tube V5A stops conducting, the plate voltage rises, and the grid voltage of V5B also rises, causing V5B to conduct and alarm ringing relay K2 to become energized. As previously explained, when pulses are not present, the relay throws, causing an alarm to sound (indicating malfunction). Resistor R43 is the plate resistor of V5A. Its cathode is connected through R28, a bias divider, to R25 to ground, and to R27 to the demodulator pulse train input.

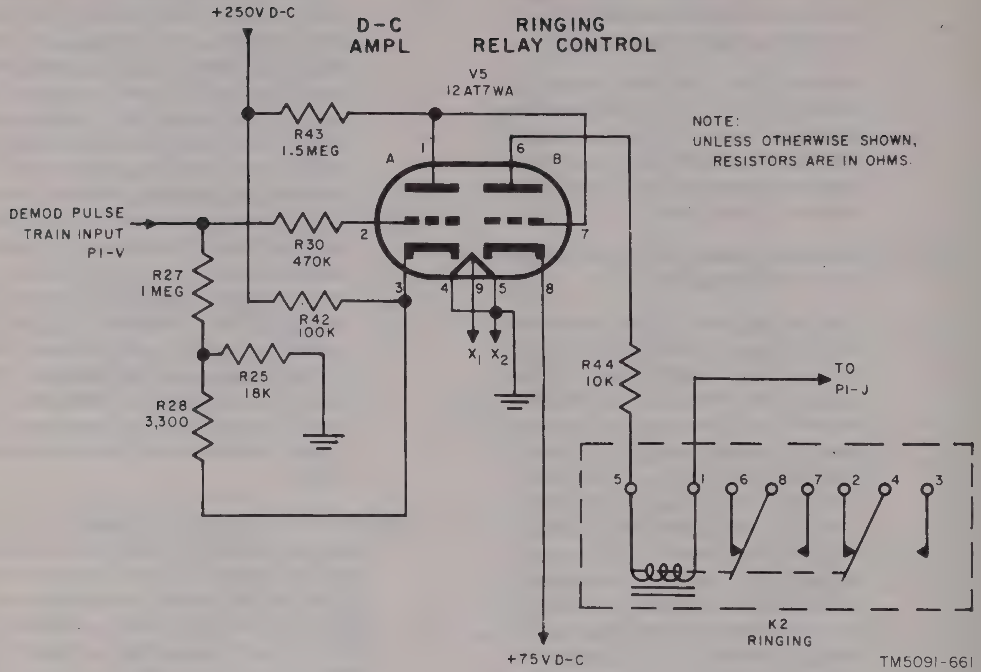

+250V D-C
D-C AMPL
RINGING RELAY CONTROL
V5
12AT7WA
NOTE:
UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS.
R43
1.5MEG
A
1
6
B
DEMOD PULSE TRAIN INPUT P1-V
R30
470K
2
7
R27
1 MEG
3
4
9
5
8
R42
100K
X1
X2
R25
18K
R28
3,300
R44
10K
TO P1-J
5
1
6
8
7
2
4
3
K2
RINGING
+75V D-C
TM5091-661

Figure 121. Modem ringing amplifier stage V5.

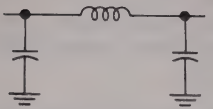
126. Delay Line Circuit

a. A delay line is a filter, or a group of filters, that have the characteristic of delaying the input signal, so that the output is later in time than the input. This is caused by the fact that one of the fundamental properties of filters is phase shift. When a number of sections are cascaded, the phase shift becomes additive, and of considerable size (subpar. *b* below). The delay line circuit consists of 16 independent 10.4-microsecond delay lines. Eight delay lines are associated with each direction of transmission, four for the multiplexer half of the drop and insert and four for the demultiplexer half of the drop and insert. Each of the delay lines provides eight separate outputs, each delayed by 5.2 microseconds from the adjacent one, to maintain the time position of the channels.

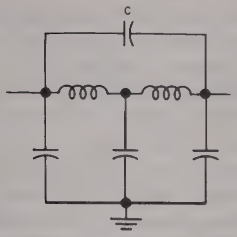
b. A basic section of the delay line is shown in A, figure 122. The entire line consists of repeated sections of this kind connected to give the desired total time delay. Taps are brought out for the connections to the resistance-capacitance shaping circuit. Each single section is basically a pi-section, constant K, low-pass filter. Each individual section is referred to as a coil section. When two sections are combined (B, fig. 122), a capacitor C is connected across the combination (to correct phase distortion). The sections are connected in series to give greater delay.

c. The delay at each section junction is approximately 1.05 microseconds. Five of these sections in series make a nominal 5.2-microsecond delay between successive taps. A tap is always available within 1 microsecond of the correct position.

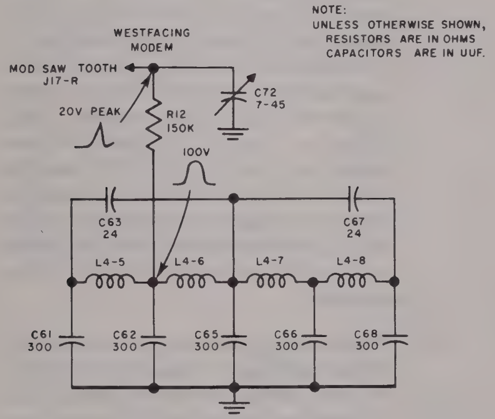
d. Each of the output taps of the delay line is connected to the respective modem modulator through an integrating circuit which consists of a series resistor and shunt capacitor (C, fig. 122). This circuit changes the gate into a sawtooth waveshape. The capacitor is adjustable to compensate for the different capacitances of the



A. ONE-HALF OF DELAY LINE SECTION



B. FULL DELAY LINE SECTION



NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF.

C. DELAY LINE INTEGRATING CIRCUIT

TM5091-615

Figure 122. Delay line section.

varying length of shielded wire to the individual modulators. This adjustment is made at the factory and normally would only be changed when a delay line is replaced. The sawtooth voltages to the individual modulators have an amplitude of 20 volts and a rise time of approximately 8 microseconds.

127. Modulating and Multiplexing Circuit (Waveshape Supplied to Modems for Modulation)

a. General. To provide the properly shaped and timed sawtooth pulses to the modulators in the modems, a positive 8-microsecond gate must be fed to a modem delay line. This is obtained by inverting and stretching the 4-microsecond negative gate which is fed into the demodulator delay line at J8 of the video restorer. The demodulator delay line is purposely terminated with a 3,000-ohm resistance, R18 and R35 (fig. 263), which is lower than its nominal characteristic impedance of 3,900 ohms. This is done to insure that any reflections from the end of the delay line appearing back at its input will be opposite in polarity to the main input gate.

b. Inverter V26 (fig. 123). The importance of this step becomes apparent in the video restorer inverter (and stretching) stage, V26. To stretch the 4-microsecond gate to 8 microseconds, it is necessary to integrate (stretching the base line signal) slightly with R134, R135, and C67 and then amplify the portion near the base line. B, figure 117, shows the gate before integration and A, figure 123, shows the gate *after* integration. If any irregularities in the base line are of positive polarity, they are clipped by the grid since the tube operates at zero bias. If they appear with the same polarity as the gate to be amplified, they will appear as full amplitude gates in the output of inverter V26 and cause each channel modulator to generate more than one pulse. This condition is prevented by using the 3,000-ohm termination on the demodulator delay line. The amplified and stretched output as shown at A, figure 124, is applied to the grid of gate amplifier V27. Capacitor C66 is the coupling capacitor, R136 and R137 are the plate resistors, R138 is the screen resistor, C69A is the screen bypass, and C68 is the output coupling capacitor.

c. Gate Amplifier V27 and Clipper V18A (fig. 124).

(1) The output of inverter V26 is fed to the control grid of cathode follower gate amplifier V27. The cathode follower output across resistor R142 drives a positive gate into the modulator delay line. The gate output of V27 is maintained at a maximum of 105 volts by the action of diode clipper V18A. When the gate voltage across R142 exceeds 105 volts, clipper V18A will conduct to clip the voltage. The +105 volts dc for the cathode of clipper V18A is provided by gas voltage

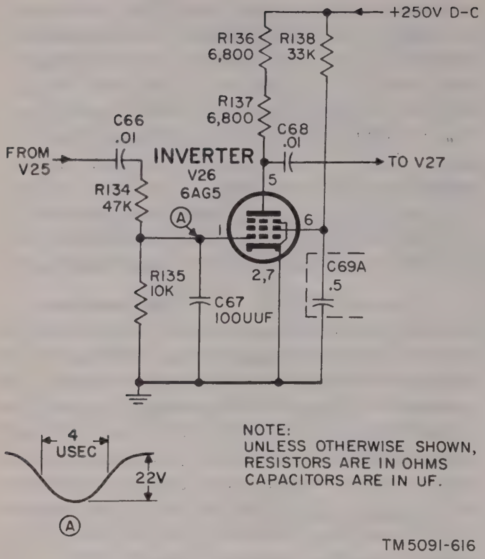


Figure 123. Inverter V26.

regulator tube V28. This gate output voltage is critically regulated because the stability of the gate amplitude determines the stability of the individual channel pulse position.

(2) Resistor R140 is the grid return, R141 is a clipping resistor, R142 is the cathode load resistor, R143 is a series voltage dropping resistor for gas tube V28, and C69B is the bypass capacitor across the 105-volt supply. The output of V27 is taken through C70 to E6 (MTPX GATE) and (MTPX GATE OUTPUT) and through R144 across an 8-kc tuned circuit, L17 and C71, to J10 (SCOPE SYNC), to provide the oscilloscope with a synchronizing gate.

128. Insertion of Channel Pulses into Pulse Train

(fig. 125)

a. General. The local modem generated and modulated channel pulses (which occur at the time the received channel pulses have been blanked) are fed into MODEM CHAN PULSES INPUT jack J5. A voltage divider network, which consists of R79 and R80, provides an 11-volt drop across R79. A common bias of 11 volts for the local modulator tubes of all the modems is obtained at J5.

b. Cathode Follower V11 and Shaper-mixer Amplifier V12.

(1) The 4- to 7-volt modem channel pulses (G, fig. 125) are developed across R80 and directly coupled to the grid of V12B from MODEM CHAN PULSES INPUT jack J5. This direct coupling between the cathode of modem tube V2B and the grid of V12B prevents the larger amplitude pulses from suppressing those of lower amplitude as would happen with conventional-type coupling and its attendant grid leak bias. (Paragraph 116*b* provides additional pulse insertion information.) The plate of V12B is in parallel with blanking tube V11B, and the two share a common plate load resistor, R67. Since the channel pulses are impressed on the grid of V12B and the plate is in parallel with the plate of V11B, the signal at the plate of V12B consists of the entire pulse train with new locally generated channel pulses inserted.

(2) This entire pulse train is then amplified and shaped in shaper V12A in a manner similar to that of shaper V4. These pulses are then fed to pulse amplifier V10A where further reshaping takes place as explained in paragraph 121. Refer to paragraph 130 for a detailed description of cathode-follower and blanker tube V11.

(3) For cathode follower tube V11A, R65 is the grid resistor. Resistor R65 is the signal input load resistor, and R66 is the cathode follower output load resistor. The signal voltage developed across R66 is fed through capacitor C38 to the grid of V11B.

(4) For blanker tube V11B, R67 is the plate load and R68 provides the blanking load. Resistor R69 with capacitor

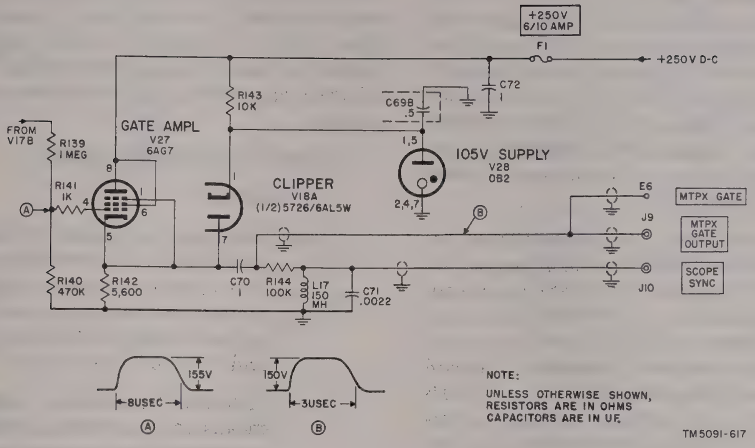

+250V
6/10 AMP
F1
+250V D-C
C72
1
R143
10K
C69B
.5
1,5
105V SUPPLY
V28
0B2
2,4,7
FROM
V17B
R139
1 MEG
GATE AMPL
V27
6AG7
8
R141
1K
4
1
6
5
A
CLIPPER
V18A
(1/2) 5726/6AL5W
1
7
B
E6
MTPX GATE
J9
MTPX
GATE
OUTPUT
SCOPE
SYNC
J10
R140
470K
R142
5,600
C70
1
R144
100K
L17
150
MH
C71
.0022
155V
8USEC
150V
3USEC
A
B
NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
TM 5091-617

Figure 124. Gate amplifier V27 and clipper V18A.

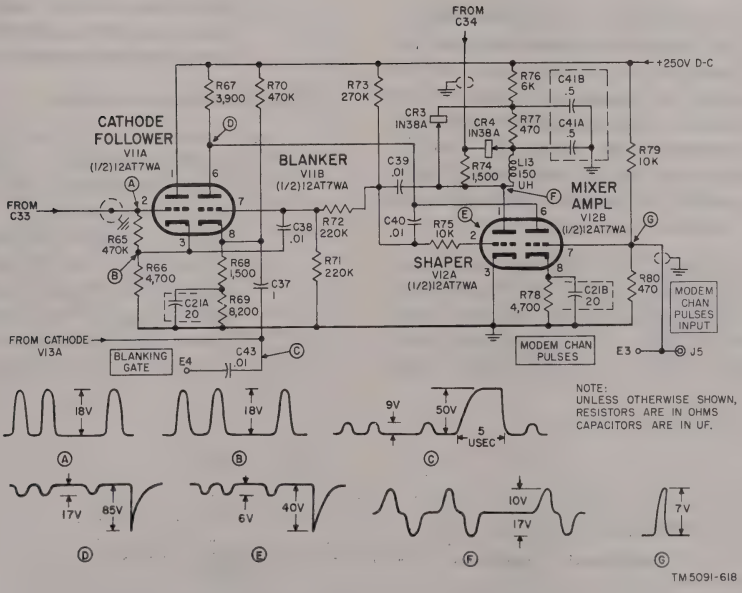

FROM
C34
+250V D-C
R67
3,900
R70
470K
R73
270K
R76
6K
C41B
.5
CR3
1N38A
CR4
1N38A
R77
470
C41A
.5
CATHODE
FOLLOWER
V11A
(1/2)12AT7WA
D
BLANKER
V11B
(1/2)12AT7WA
C39
.01
R74
1,500
L13
150
UH
F
R79
10K
MIXER
AMPL
V12B
(1/2)12AT7WA
FROM
C33
A
2
1
6
7
3
8
R65
470K
B
R66
4,700
C38
.01
R72
220K
C40
.01
R75
10K
E
2
1
6
7
3
8
G
SHAPER
V12A
(1/2)12AT7WA
R68
1,500
C37
1
R71
220K
C21A
20
R69
8,200
R78
4,700
C21B
20
R80
470
MODEM
CHAN
PULSES
INPUT
FROM CATHODE
V13A
BLANKING
GATE
E4
C43
.01
C
MODEM CHAN
PULSES
E3
J5
18V
18V
9V
50V
5
USEC
A
B
C
NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
17V
85V
6V
40V
10V
17V
7V
D
E
F
G
TM 5091-618

Figure 125. Cathode follower-blanker V11 and shaper-mixer amplifier V12.

C21A assists in the rapid decay of the blanking pulse (C, fig. 125). The voltage divider network of resistors R70, R68, and R69 provides a voltage which places the cathode of V11B at a fixed +12 volts. A blanking gate from cathode follower V13A is fed through C37 to V11B. Resistors R71, R72, and R73 form a voltage divider network applying the proper grid voltages to tubes V11B and V12A.

(5) Resistor R78 is the cathode-bias resistor for V12B and is bypassed by C21B. Capacitor C40 is the input coupling capacitor for V12A, R73 is the grid return, and R75 is a series grid limiting resistor. Resistors R76 and R77 with capacitors C41A and C41B form a pi-type plate decoupling network. The germanium diodes CR3 and CR4 clip the top and bottom of the pulses which have been narrowed to about ¼ microsecond by ringing coil L13 (F, fig. 125).

129. Modem Modulator Circuit

(fig. 126)

a. General. Modulation of the pulse train is accomplished in 16 individual and identical modem units. These units include provision for signaling and provide means for either two- or four-wire operation. The modulator section of the modem consists of two tubes, V1 and V2. The modulator converts the audio input signal into a pulse which is position-modulated and may then be inserted in the pulse train.

b. Block Diagram. A functional block diagram is shown in figure 126. The two-wire or four-wire line signal is fed into hybrid transformer T1. The output of T1 is fed into a crystal diode clipper (CR1 and CR2) which limits the modulation to a specific maximum value corresponding to a four-wire input of —4 dbm. The clipped audio signal is then fed to audio amplifier tube V1A from which it goes into ppm tube V1B. The output is then clipped and shaped in tube V2A and fed through cathode-follower tube V2B to the video restorer mixer circuits.

c. Hybrid Transformer (fig. 127).

(1) *General.*

(*a*) Provision is made in the modem for either two- or four-wire operation. The audio input and output information can be carried on two wires or four wires (two for transmitting and two for receiving).

(*b*) A hybrid transformer is basically a means for converting between two- and four-wire operation, as well as an input and output matching device. The most common type of hybrid is shown in A, figure 127. Winding a is the modulator input, windings b and c contain a neutralizing network, N, which matches the input line, winding d goes to the demodulator output, and windings e and f in series are the line input. Note the two separate cores.

(2) *Two-wire operation.*

(*a*) Consider the action when a signal is being received from the line. One-half of windings e and f are shorted by the connection of terminals 10 and 13. The line signal is coupled to each of two independent cores through windings e and f. Line signal voltages will, therefore, be induced into all other windings, a, b, c, and d. The voltages developed

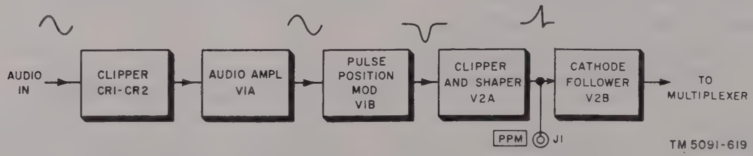


Figure 126. Modem modulator, block diagram.

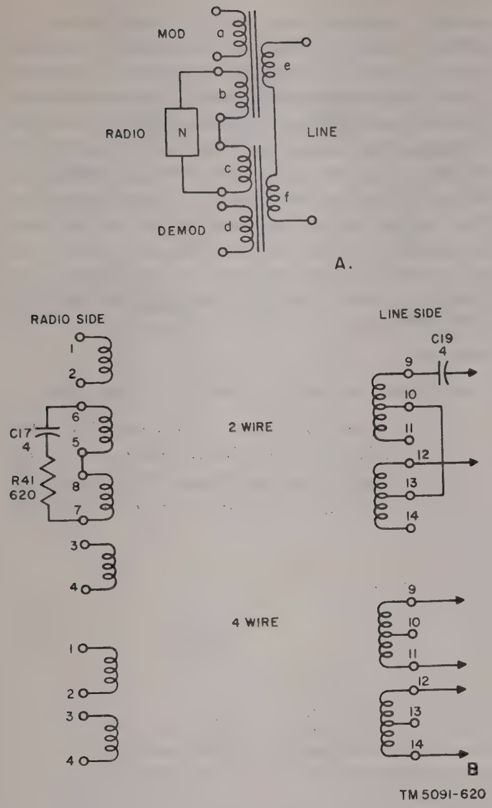


Figure 127. Modem hybrid transformer connections.

across windings b and c are equal but opposite in polarity so that the two induced voltages applied to the N network buck each other and cancel; hence, no power is lost in the network. Windings a and d are similar and therefore half the power appears across each. The section that appears as the demodulator winding is applied to the plate of audio amplifier V4B and is lost. The fact that half the power is lost means a 3-db loss is encountered in passing a two-wire input through the hybrid.

(*b*) Now consider the action in receiving a signal from the demodulator (winding d). The power applied to winding d comes from audio amplifier V4B. Since winding d is coupled to one core only, a voltage is induced in windings c and f. These induced voltages cause current to flow in both the line and network circuits. The line voltage (f) will be opposite to the applied demodulator voltage (d) and the network voltage (c) will be of the same polarity as the demodulator voltage (d). Note that if the network impedance accurately matches the line impedance, equal currents will flow through these circuits and through windings b and e. Windings b and e are so polarized that the currents in these windings produce opposing magnetizing forces in the core (of the upper transformer) ; hence, no flux changes are produced, and no voltages are produced in winding a. The result is that the demodulator signal is not fed to the modulator, and hence no undesirable feedback signal results. It is this action for which the hybrid transformer is primarily provided.

(3) *Four-wire operation.*

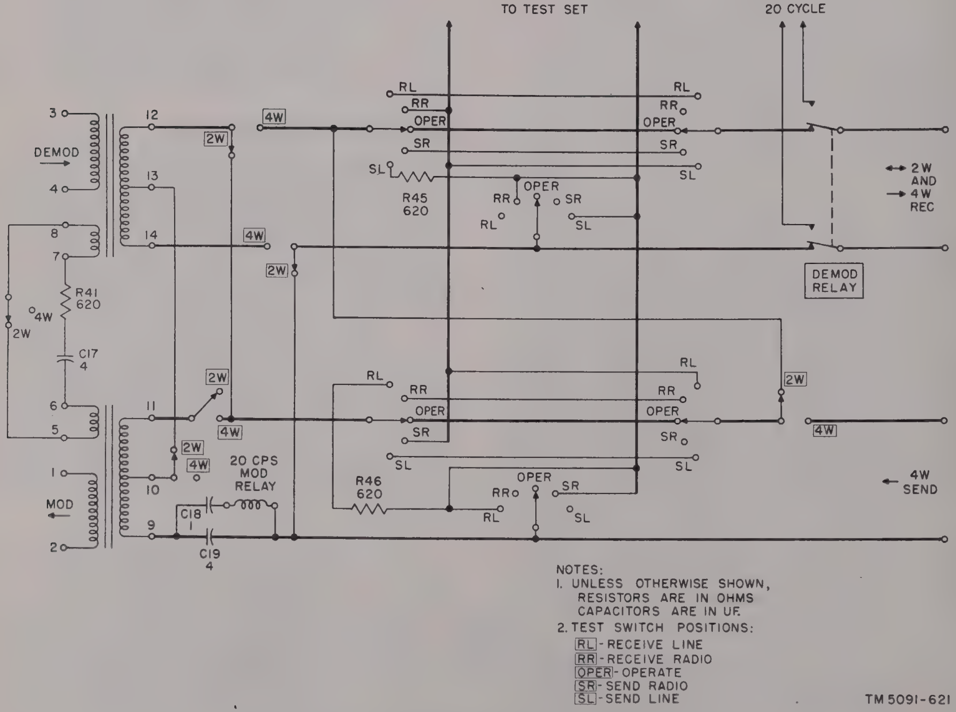
(*a*) Note that since the network winding is open, the line side windings are separated, and since the cores are independent, there are now in effect two separate line transformers. Removing the connection between terminals 10 and 13 gives each winding (e and f) the same number of turns as the single connection for two-wire operation. This hybrid circuit change from two-wire to four-wire operation is accomplished by the 2W-4W switch in the modem.

(*b*) In four-wire operation, there are essentially two transformers with an impedance ratio of 50 to 1 (30,000 ohms to 600 ohms). In two-wire operation, parts of the two-line side windings are connected in series to give 600 ohms. The network windings are identical to these parts of the line side windings and the network is therefore chosen to match a typical line, and is termed a *compromise network.* The modulator and demodulator windings remain 30,000 ohms. In four-wire operation, windings 5-6 and 7-8 are open. Resistors R45 and R46 are terminating resistors for the test pair on one side of the hybrid. Capacitor C18 is a d-c blocking capacitor isolating the 20-cps modulator relay from any dc that might be on the line, and C19 bypasses the audio frequencies from the line around the 20-cps modulator relay.

d. Modem Switching. Modem switching (fig. 128) is accomplished by two switches, 2W-4W switch S1 and selector switch S2. The 2W-4W switch connects the hybrid transformer for either two- or four-wire operation. Selector switch S2 has five positions; in the OPER position, the modem is totally disconnected from the test set, and connected to its output; in the SL position, the output from the test set generator is fed to the line; in the SR position, the test set output is fed to the modem; in the RR position, the output of the modem is fed to the level measuring section of the test set; and in the RL position, the output is fed to the line. The selector switch basically controls a pair of lines (TEST PAIR) between the modem and the test set.

e. Audio Amplifier Stage V1A (fig. 129).

(1) Tube V1A is an audio amplifier that amplifies and limits the audio signal applied across resistor R2. Degeneration is provided by the unbypassed



NOTES:
1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS CAPACITORS ARE IN UF.
2. TEST SWITCH POSITIONS:
RL - RECEIVE LINE
RR - RECEIVE RADIO
OPER - OPERATE
SR - SEND RADIO
SL - SEND LINE

Figure 128. Modem switching circuit, simplified diagram.

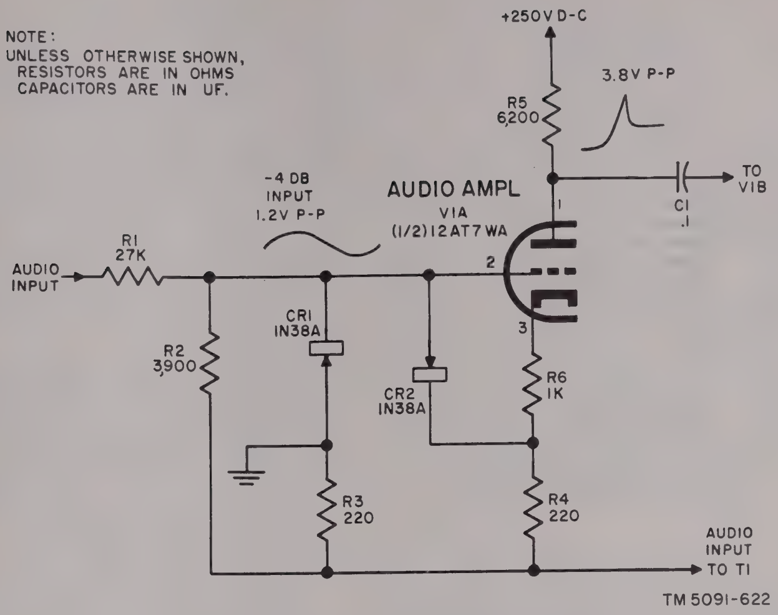

NOTE:
UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS CAPACITORS ARE IN UF.
+250V D-C
R5 6,200
3.8V P-P
TO V1B
C1 .1
AUDIO AMPL
V1A (1/2) 12AT7WA
-4 DB INPUT 1.2V P-P
AUDIO INPUT
R1 27K
R2 3,900
CR1 1N38A
CR2 1N38A
R3 220
R6 1K
R4 220
1
2
3
AUDIO INPUT TO T1
TM 5091-622

Figure 129. Clipper audio amplifier stage V1A.

cathode resistor R6. Crystal diodes CR1 and CR2 limit the audio input signal to prevent excessive modulation or deviation of the channel pulse beyond ±.5 usec. Overmodulation will cause an undesirable deviation of more than ±.5 usec.

(2) Limiting is accomplished in the following manner. The cathode of tube V1A develops a positive voltage caused by Class A type plate to cathode current. One side of R2 is connected to the grid and the other to a-c ground. The audio input is applied through R1 to the grid. A bias of –.6 volt exists at the junction of R2, R3, and R4. When the input signal is greater than .6 volt, and negative, clipper crystal CR1 conducts, cutting off the signal above that level. When the signal is greater than .6 volt, and positive, CR2 conducts, cutting off the signal above that level. In this way, effective limiting of the audio signal applied to the first stage audio amplifier is obtained. Resistors R1 and R2 are a voltage divider on the input voltage to provide correct input level. The audio signal developed across plate load resistor R5 is fed to the cathode of V1B through coupling capacitor C1.

f. Pulse-position Modulator Stage, V1B (fig. 130).

(1) Position modulation is accomplished in tube V1B. This stage is normally kept near cutoff by the large bias developed across cathode resistors R8 and potentiometer R9 (PULSE POSITION). Two inputs are fed to this stage. One, the sawtooth, is applied to the grid of V1B from the delay line. The other is the amplified audio signal from the plate of V1A and is fed to the cathode of V1B.

(2) The a-f signal applied to the cathode of V1B varies the value of the cathode voltage above and below the nor-

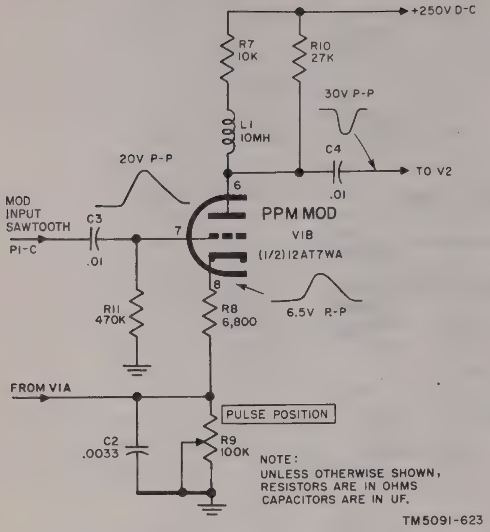


Figure 130. Pulse-position modulator V1B.

mal zero signal value. The sawtooth wave applied to the grid causes plate current to flow when the actual bias (grid-to-cathode voltage or a-f voltage +sawtooth voltage +bias voltage) is approximately –5 volts. The value of the a-f signal applied to the cathode determines the time when this occurs, since the combination of both signals determines the next bias. Since the sawtooth is linear over the range of modulation, the variation of the time of increasing plate current is also linear. The delay line taps are selected so that the center of the sawtooth corresponds in time with the no-modulation pulse position.

(3) Resistor R11 is the grid return and C3 is the sawtooth delay line input coupling capacitor. Resistor R7 in series with inductor L1 and resistor R10 in parallel with combined R7-LI provide the plate load. Capacitor C4 is the output coupling capacitor, R8 and R9 are the cathode bias resistors, and C2 is the cathode-bypass capacitor, offering high impedance at audio frequencies.

(4) Changing potentiometer R9 will change the cathode bias and therefore the unmodulated pulse position. This is a front panel control (PULSE POSITION) and is provided so that no adjustment of the delay line is necessary.

(5) The plate waveshape generated across L1 is critically damped by resistors R7 and R10 and a single broad pulse results.

(6) Modem clipper-shaper-mixer tube V2A (fig. 131) has its cathode grounded and its grid returned to a positive potential through resistors R12 and R13 to insure heavy plate current in the absence of the signal. The negative input pulse is applied to the grid of tube V2A through a 10,000-ohm resistor, R13. This large negative input pulse is of sufficient strength to cut off the tube. This produces a positive pulse at the plate through the differentiating action of the plate circuit components (inductor L2 in parallel with the resistor-crystal combination of R17 and CR3, and parallel resistor R16), which ring for a time determined by the component values. These oscillations are damped by diode CR3. The positive output pulse is applied to mixer cathode-follower tube V2B through capacitor C6. Mixer tube V2B has a load in common with the load of the same tube in all the modulators. This load, R80, is located in the video restorer. Resistors R14 and R15 are in series with inductor L2 and form the plate load of tube V2A. For channels 1 and 2 only, the plate of tube V2B goes to the remote keying unit. For channels 3 through 8 the plate of V2B is connected to the +250-volt d-c supply. The modem modulator output pulse is taken from the cathode of V2B.

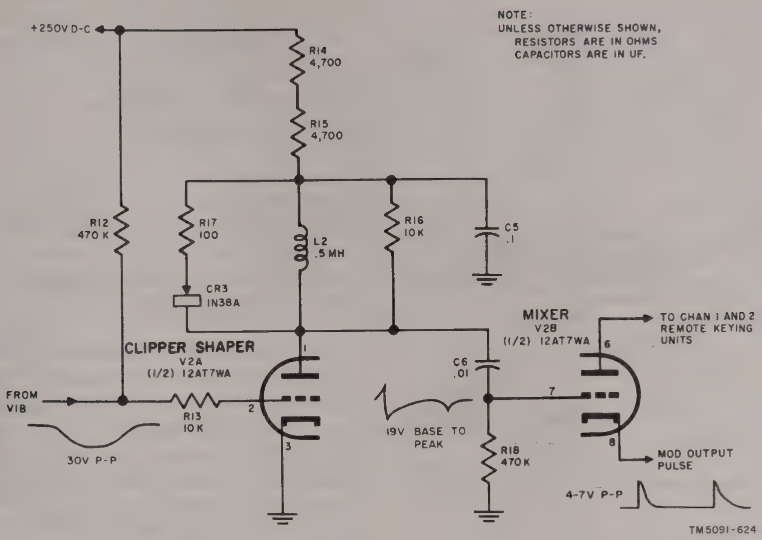

NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
+250V D-C
R14
4,700
R15
4,700
R12
470 K
R17
100
L2
.5 MH
R16
10 K
C5
.1
CR3
IN38A
MIXER
V2B
(1/2) 12AT7WA
TO CHAN 1 AND 2
REMOTE KEYING
UNITS
CLIPPER SHAPER
V2A
(1/2) 12AT7WA
C6
.01
FROM
V1B
R13
10 K
2
1
3
7
6
8
19V BASE TO
PEAK
R18
470 K
30V P-P
MOD OUTPUT
PULSE
4-7V P-P
TM5091-624

Figure 131. Modem clipper-shaper-mixer tube V2A and mixer tube V2B.

130. Blanking and Insert Circuit

a. General. The blanking gates are signals that cut off the blanking tube at the time a channel pulse is being received so that the blanking tube cannot pass the pulse. Each gate *blanks* a channel. The taps on the demodulator delay line (corresponding to the individual channel time positions) provide the signals for blanking. These signals are negative gates about 4 microseconds wide and are mixed through resistances about 100K and fed to the grid of V13B to be amplified (fig. 132). The amplitude of the blanking gate is 7 to 8 volts peak to peak.

b. Amplifier V13B and Cathode Follower V13A (fig. 132). The blanking gate is taken from INPUT BLANKING GATES J6 and applied through coupling capacitor C44 to the grid of V13B (B, fig. 132). Tube V13B is an amplifier and grid limiter. The blanking gate is amplified by V13B to a high level (A, fig. 132), then fed through cathode follower V13A to the cathode of blanking tube V11B. A sample of the signal being fed to the cathode of V11B is brought out to E4 test point through capacitor C43. For V13B, resistor R85 is the grid return to B+. Resistors R81 and R82 in parallel provide the plate load, and C42 is the output coupling capacitor that couples the signal from V13B to the grid of V13A. Resistor R83 is the grid return, and R84 is the cathode load resistor for tube V13A.

c. Blanking Tube V11B.

(1) The grid of blanking tube V11B (fig. 125) receives the entire positive pulse train from the output of V9 through isolating cathode follower V11A. The first cathode follower (V13A) provides a low-impedance source from which to drive the blanking gates into cathode resistor R68 of the blanking tube. The second cathode follower V11A is used to isolate the grid of shaper V19 from the grid of V11B as follows: The locally generated and inserted channel pulses will appear on the plate of blanking tube V11B. These pulses may be coupled to the grid of V11B through the grid-to-plate capacitance of the tube. If these low-amplitude pulses were to reach the grid of V19, a phenomenon would take place which is known as *reverse-feedthrough* cross

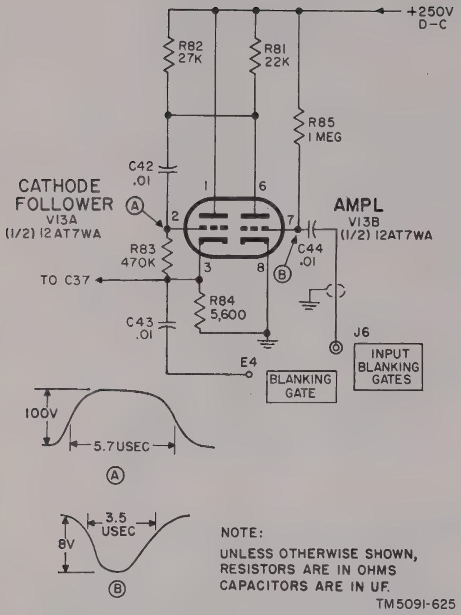


Figure 132. Cathode-follower amplifier V13.

talk. That is, modulation on a locally generated channel pulse would cross talk into the local demodulator that faces the opposite r-f direction from that of the demodulator.

(2) In blanking tube V11B (fig. 125), the cathode is biased below cutoff so that the channel pulses appearing on the grid (B, fig. 125) drive the tube into conduction. The positive blanking gates that appear on the cathode of this tube (C, fig. 125) drive the bias further into cutoff; therefore, channel pulses that occur at the time of a blanking gate cannot cause the tube to conduct and will not appear in the output at the plate of V11B. The output of the blanker tube will have a waveshape similar to one shown in D, figure 125. Resistor R67 is the plate resistor of V11B, and R68, R69, and R70 form a voltage divider that supplies bias to the cathode. Part of the cathode resistance (R69) is bypassed by C21A. Resistor R71 is the blanker grid return resistor.

131. Audio Terminations

(fig. 133 and 134)

a. Following is a description of the party-line termination on the order wires of Multiplexer Group AN/TCA–1. Party line is a connection where the operators at both ends of the system and the operator at the repeater talk to one another.

b. For party-line operation, the modems are terminated as four-wire units. The output of the four-wire receive line of each modem feeds the 600-ohm input of the four-wire transmit line of the sending modem in parallel with a 600-ohm hybrid. Each demodulator feeds 300 ohms and is mismatched two to one. This causes a 1-db loss in power transmission. In addition, there is a power split between the four-wire transmit line and the hybrid, which causes a net loss of 4 db. For the local line, there is an additional 4-db loss through the hybrid.

c. The normal listening level is –4 dbm, and the normal level into the modulator is –4 dbm for 100 per cent modulation. Therefore, for the party-line connection, if the demodulator output is adjusted to 0 dbm, the modulator input level is –4 dbm. This causes 100 per cent modulation and no loss for the through connection. As shown in the block diagram (fig. 133), the listening level at the local line is –8 dbm or only 4 db below that of a terminal. If the sending level from the local line is 0 dbm, it will cause a modulating level of –8 dbm or only 4 db below that of a terminal.

d. A local line at the repeater will listen to a terminal station 4 db down from normal, and will be heard at a terminal station 4 db down from normal. For repeater-to-repeater communications, the local line will hear and be heard 8 db below normal. However, there is no loss in level for terminal-to-terminal communications. The terminal equipment gives a 4-db net loss circuit on each channel. This is maintained regardless of the number of repeater stations that have the proposed party-line connection on the order wire. For party-line

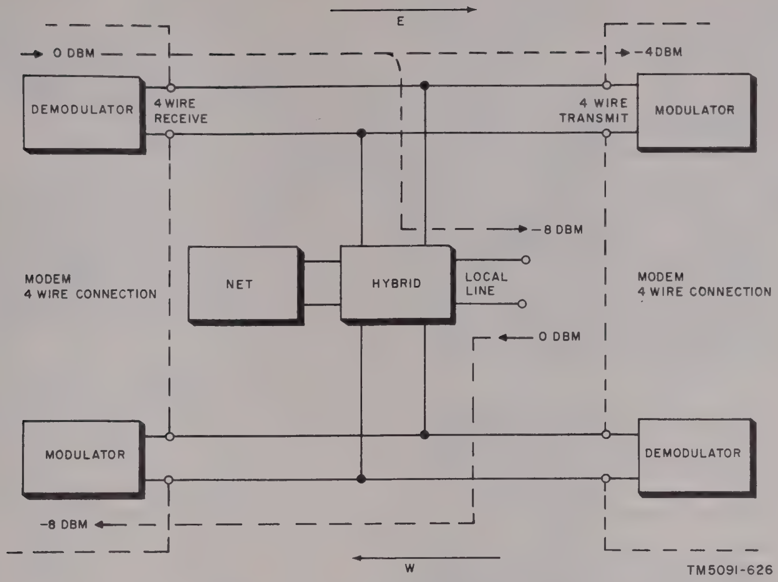

E
→ 0 DBM
→ −4DBM
DEMODULATOR
4 WIRE RECEIVE
4 WIRE TRANSMIT
MODULATOR
→ −8 DBM
MODEM 4 WIRE CONNECTION
NET
HYBRID
LOCAL LINE
MODEM 4 WIRE CONNECTION
← 0 DBM
MODULATOR
DEMODULATOR
−8 DBM ←
W
TM5091-626

Figure 133. Party-line audio terminations.

connection, two hybrid coils and appropriate terminating networks are provided in the rack, one for each channel.

e. When the audio termination is private, the unit may be connected by either two- or four-wire, and gives two independent circuits, one eastfacing and one westfacing.

132. Remote Keying Circuit

a. General.

(1) *Description.*

(*a*) Remote keying remotely switches the operation of units associated with the remote keying terminals. The remote keying unit is described physically in paragraph 17. Each assembly consists of two identical subunits mounted side by side. These units are alike, except for reference symbol numbering. Plugs P1 and P2 on these units have been modified so that they will match a receptacle when inserted with either end up. The assembly may be turned upside down and may still be plugged. When the whole unit is reversed in this manner, the two subunits are not only reversed, but each one is now inserted into the receptacle formerly occupied by the other. This action is used to switch from normal to remote operation.

(*b*) The double arrangement described above is necessary for the operation of the units at repeater stations and was used also at the terminals to standardize the construction of the remote keying units.

(*c*) Figures 135 and 136 show the keying signal path. These figures show all pin and terminal connections in this path from the modem through the mounting rack and remote keying unit.

(2) *Function.* The remote keying facility allows two types of remote keying operation on either or both channel 1 and channel 2.

(*a*) To permit an operator, located at a multiplex location, to control a vhf fixed station located near another multiplex location.

(*b*) To permit a vhf mobile unit to *talk through* a vhf fixed station at a multiplex location, then through a microwave system (such as Radio Set AN/TRC–29) to another multiplex location, then through another vhf station to a second mobile unit.

Note. Multiplex location designates a Multiplexer Set AN/TCC–13 terminal, a Pulse Form Restorer Group AN/TRA–10 repeater, or a Multiplexer Group AN/TCA–1 repeater, because all these act similarly for remote keying operation.

(*c*) Basically, remote keying is accomplished by having the given channel pulse normally missing or blanked out (in the idle condition). The keying signal causes the pulse to be inserted, and it is the presence of the pulse at the far terminal that provides the operation of the keying contacts. The audio (voice) signal is always accompanied by the keying signal; thus the channel pulse is always available to carry the audio signal.

b. Remote Keying Operation.

(1) *Between multiplex location and mobile unit* (fig. 24). For the east operator to talk through the vhf transmitter at the west terminal, the operator must close his remote keying switch, which causes the following:

(*a*) Since this switch is connected to the REMOTE KEYING IN binding posts at the multiplexer set, this short-circuits these binding posts. This, in turn, causes the pulse for the given channel to be inserted in the pulse train and to be sent through Radio Set AN/TRC–29 (or some other applicable radio set) to the west terminal. The presence of this pulse at the west terminal causes a relay to operate which causes the vhf transmitter to be *keyed on*. Thus, when

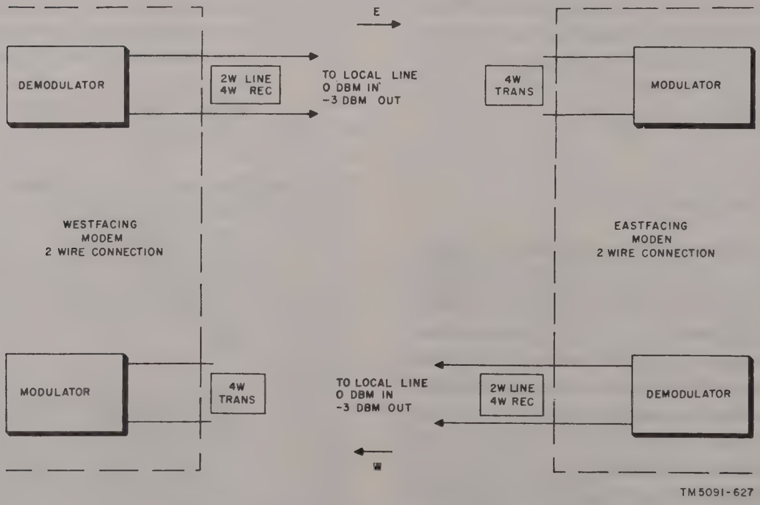
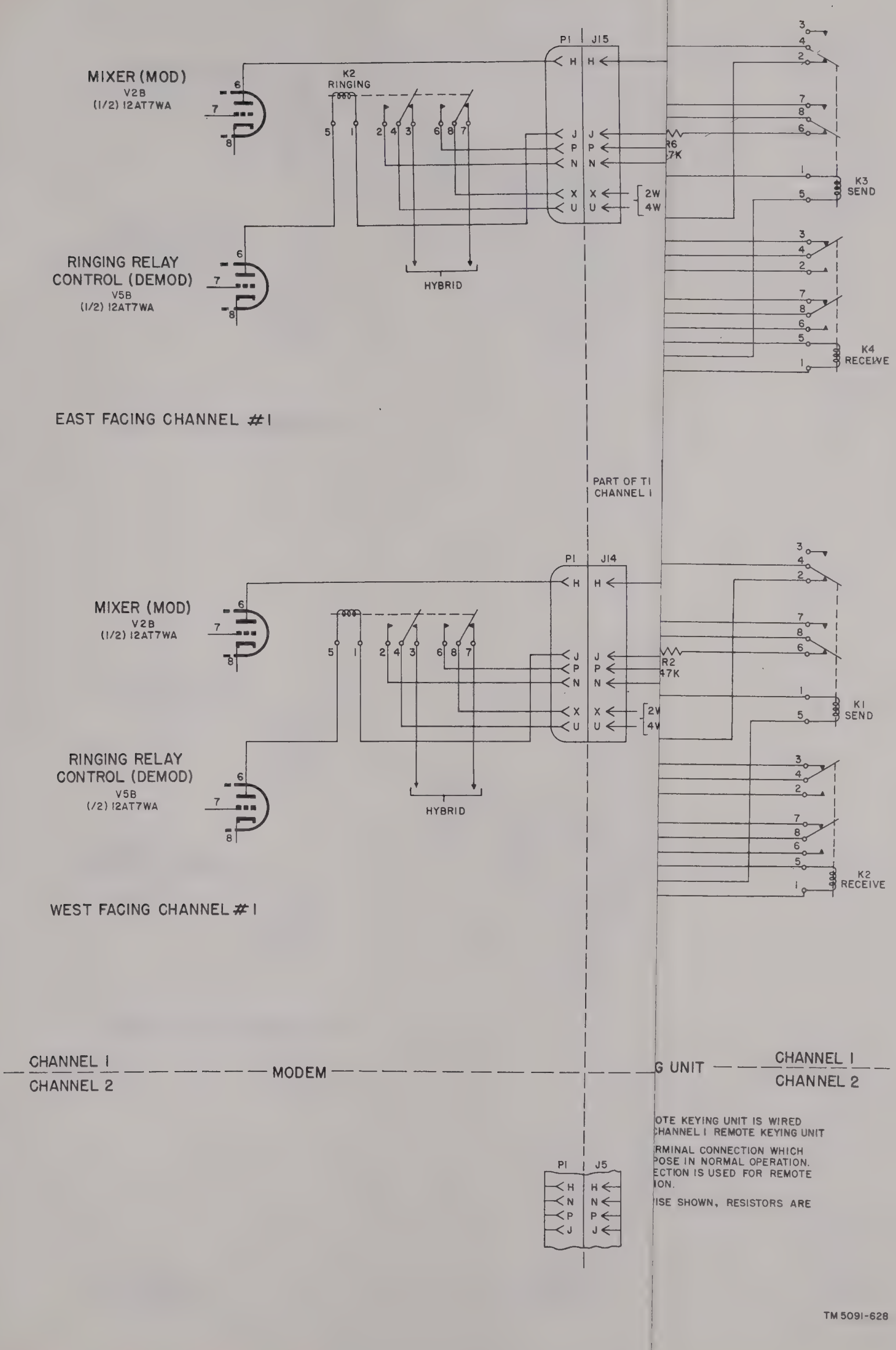

E
DEMODULATOR
2W LINE
4W REC
TO LOCAL LINE
0 DBM IN
-3 DBM OUT
4W
TRANS
MODULATOR
WESTFACING
MODEM
2 WIRE CONNECTION
EASTFACING
MODEN
2 WIRE CONNECTION
MODULATOR
4W
TRANS
TO LOCAL LINE
0 DBM IN
-3 DBM OUT
2W LINE
4W REC
DEMODULATOR
W
TM5091-627

Figure 134. Party-line private connections.


MIXER (MOD)
V2B
(1/2) 12AT7WA
RINGING RELAY
CONTROL (DEMOD)
V5B
(1/2) 12AT7WA
K2
RINGING
HYBRID
P1
J15
H
J
P
N
X
U
R6
47K
2W
4W
K3
SEND
K4
RECEIVE
EAST FACING CHANNEL #1
PART OF T1
CHANNEL 1
J14
R2
47K
K1
SEND
K2
RECEIVE
(/2) 12AT7WA
WEST FACING CHANNEL #1
CHANNEL 1
CHANNEL 2
MODEM
G UNIT
CHANNEL 1
CHANNEL 2
J5

OTE KEYING UNIT IS WIRED
CHANNEL I REMOTE KEYING UNIT

RMINAL CONNECTION WHICH
POSE IN NORMAL OPERATION.
ECTION IS USED FOR REMOTE
ION.

ISE SHOWN, RESISTORS ARE

TM 5091-628

Figure 135. Remote keying circuit, normal operation.

(2) *Function.* The remote keying facility allows two types of remote keying operation on either or both channel 1 and channel 2.

(*a*) To permit an operator, located at a multiplex location, to control a vhf fixed station located near another multiplex location.

(*b*) To permit a vhf mobile unit to *talk through* a vhf fixed station at a multiplex location, then through a microwave system (such as Radio Set AN/TRC–29) to another multiplex location, then through another vhf station to a second mobile unit.

Note. Multiplex location designates a Multiplexer Set AN/TCC–13 terminal, a Pulse Form Restorer Group AN/TRA–10 repeater, or a Multiplexer Group AN/TCA–1 repeater, because all these act similarly for remote keying operation.

(*c*) Basically, remote keying is accomplished by having the given channel pulse normally missing or blanked out (in the idle condition). The keying signal causes the pulse to be inserted, and it is the presence of the pulse at the far terminal that provides the operation of the keying contacts. The audio (voice) signal is always accompanied by the keying signal; thus the channel pulse is always available to carry the audio signal.

b. Remote Keying Operation.

(1) *Between multiplex location and mobile unit* (fig. 24). For the east operator to talk through the vhf transmitter at the west terminal, the operator must close his remote keying switch, which causes the following:

(*a*) Since this switch is connected to the REMOTE KEYING IN binding posts at the multiplexer set, this short-circuits these binding posts. This, in turn, causes the pulse for the given channel to be inserted in the pulse train and to be sent through Radio Set AN/TRC–29 (or some other applicable radio set) to the west terminal. The presence of this pulse at the west terminal causes a relay to operate which causes the vhf transmitter to be *keyed on.* Thus, when

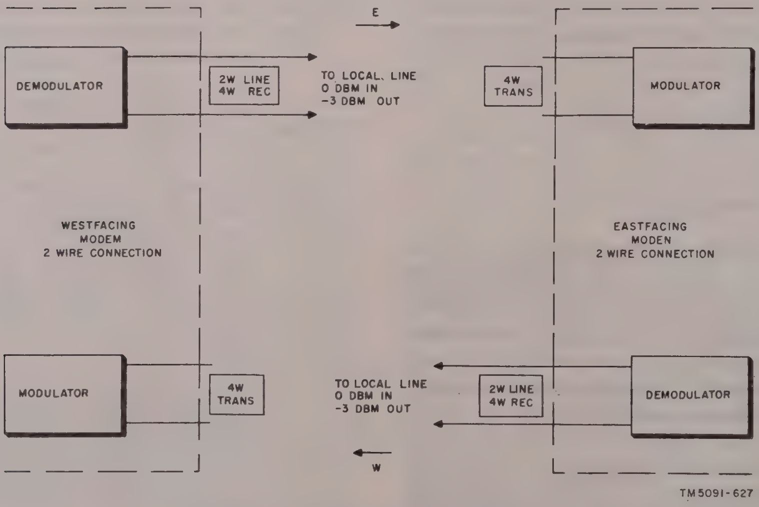
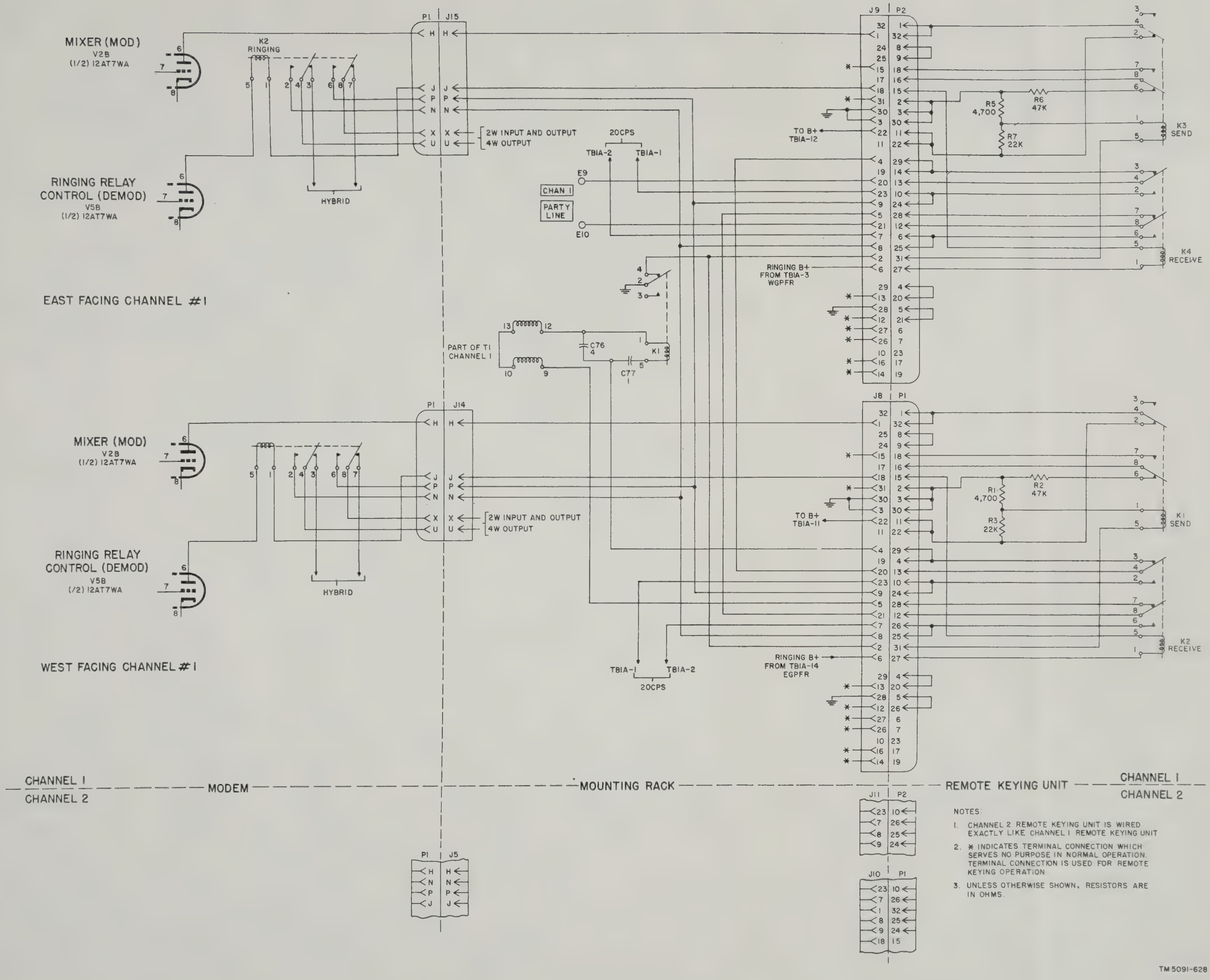

E
DEMODULATOR
2W LINE
4W REC
TO LOCAL LINE
0 DBM IN
-3 DBM OUT
4W
TRANS
MODULATOR
WESTFACING
MODEM
2 WIRE CONNECTION
EASTFACING
MODEN
2 WIRE CONNECTION
MODULATOR
4W
TRANS
TO LOCAL LINE
0 DBM IN
-3 DBM OUT
2W LINE
4W REC
DEMODULATOR
W
TM5091-627

Figure 134. Party-line private connections.


MIXER (MOD)
V2B
(1/2) 12AT7WA
K2
RINGING
RINGING RELAY
CONTROL (DEMOD)
V5B
(1/2) 12AT7WA
HYBRID
EAST FACING CHANNEL #1
WEST FACING CHANNEL #1
P1
J15
J14
J5
2W INPUT AND OUTPUT
4W OUTPUT
20CPS
TBIA-2
TBIA-1
E9
E10
CHAN 1
PARTY LINE
PART OF T1
CHANNEL 1
C76
C77
K1
TO B+
TBIA-12
TBIA-11
RINGING B+
FROM TBIA-3
WGPFR
FROM TBIA-14
EGPFR
J9
P2
J8
P1
J11
J10
R5
4,700
R6
47K
R7
22K
R1
4,700
R2
47K
R3
22K
K3
SEND
K4
RECEIVE
K1
SEND
K2
RECEIVE
CHANNEL 1
CHANNEL 2
MODEM
MOUNTING RACK
REMOTE KEYING UNIT
TM 5091-628

NOTES:

1. CHANNEL 2 REMOTE KEYING UNIT IS WIRED EXACTLY LIKE CHANNEL 1 REMOTE KEYING UNIT
2. ✱ INDICATES TERMINAL CONNECTION WHICH SERVES NO PURPOSE IN NORMAL OPERATION. TERMINAL CONNECTION IS USED FOR REMOTE KEYING OPERATION
3. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS.

Figure 135. Remote keying circuit, normal operation.

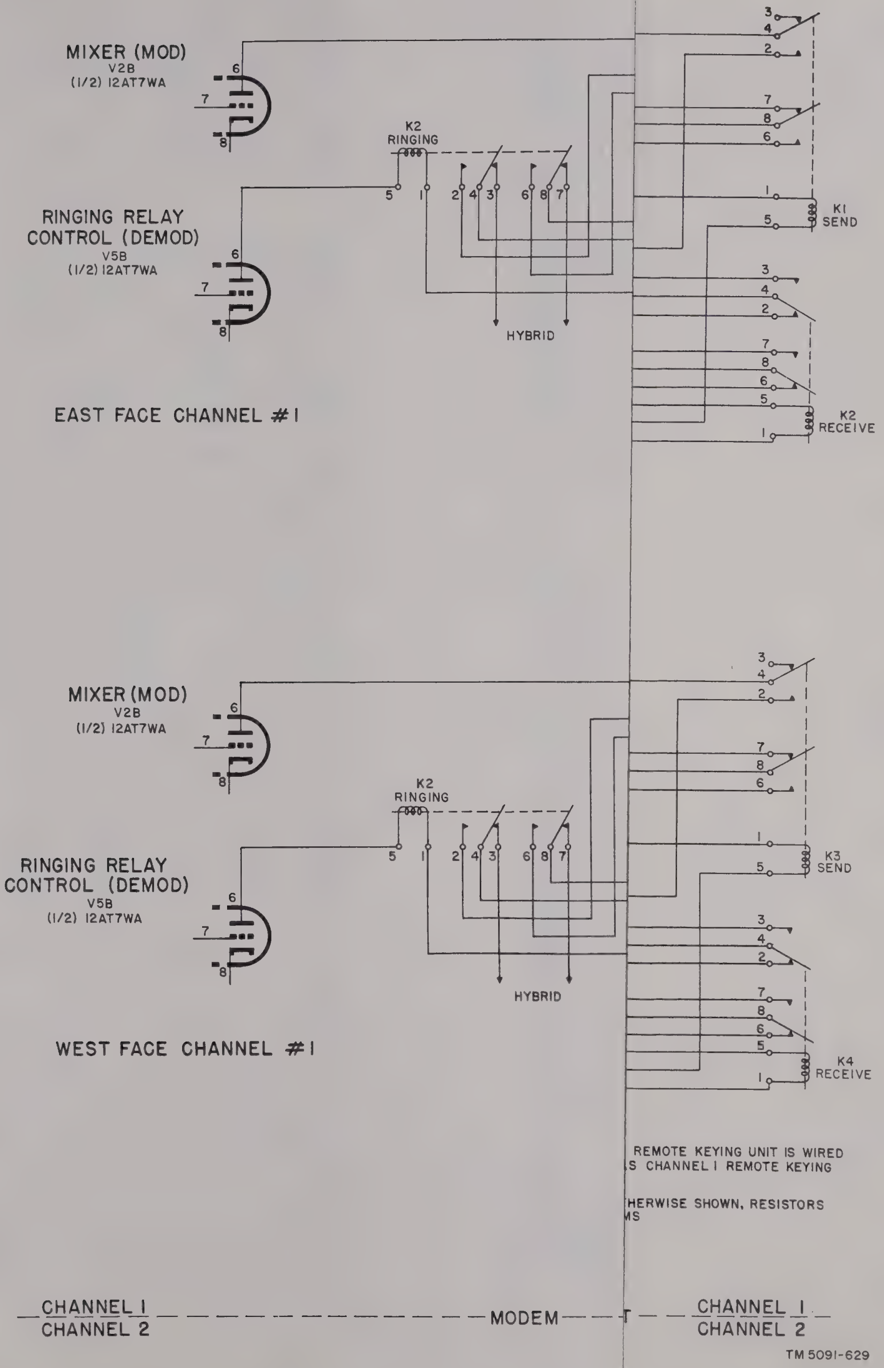
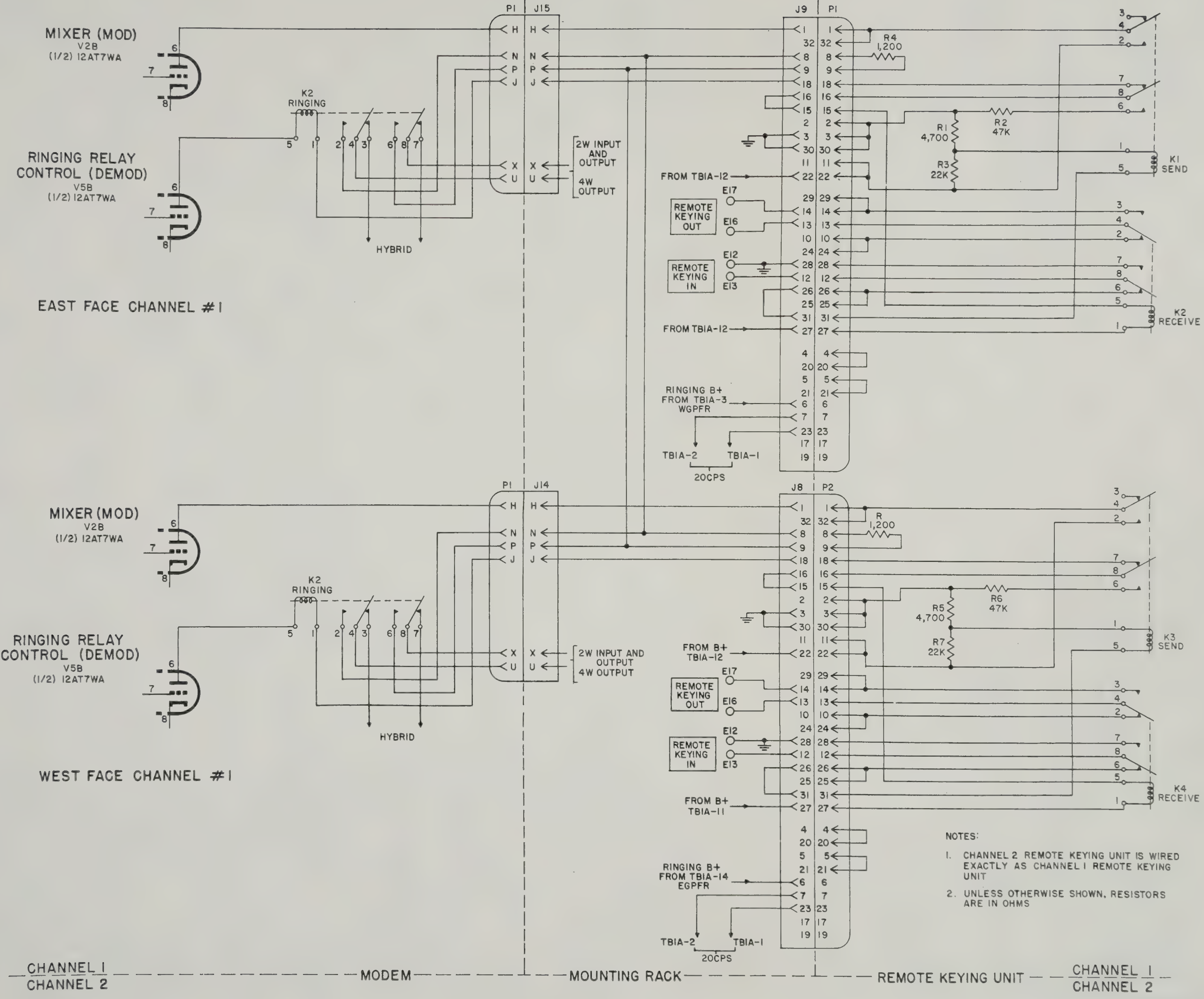

MIXER (MOD)
V2B
(1/2) 12AT7WA
6
7
8
K2
RINGING
5
1
2
4
3
6
8
7
RINGING RELAY
CONTROL (DEMOD)
V5B
(1/2) 12AT7WA
HYBRID
EAST FACE CHANNEL #1
3
4
2
7
8
6
1
5
K1
SEND
3
4
2
7
8
6
5
1
K2
RECEIVE
MIXER (MOD)
V2B
(1/2) 12AT7WA
K2
RINGING
RINGING RELAY
CONTROL (DEMOD)
V5B
(1/2) 12AT7WA
HYBRID
WEST FACE CHANNEL #1
K3
SEND
K4
RECEIVE
REMOTE KEYING UNIT IS WIRED
S CHANNEL 1 REMOTE KEYING
HERWISE SHOWN, RESISTORS
MS
CHANNEL 1
CHANNEL 2
MODEM
CHANNEL 1
CHANNEL 2
TM 5091-629

Figure 136. Remote keying circuit, remote keying operation.


MIXER (MOD)
V2B
(1/2) 12AT7WA
RINGING RELAY CONTROL (DEMOD)
V5B
(1/2) 12AT7WA
K2 RINGING
HYBRID
EAST FACE CHANNEL #1
P1
J15
H
N
P
J
X
U
2W INPUT AND OUTPUT
4W OUTPUT
J9
P1
R4 1,200
R2 47K
R1 4,700
R3 22K
K1 SEND
K2 RECEIVE
FROM TBIA-12
REMOTE KEYING OUT
REMOTE KEYING IN
E17
E16
E12
E13
RINGING B+ FROM TBIA-3 WGPFR
TBIA-2
TBIA-1
20CPS
MIXER (MOD)
V2B
(1/2) 12AT7WA
RINGING RELAY CONTROL (DEMOD)
V5B
(1/2) 12AT7WA
K2 RINGING
HYBRID
WEST FACE CHANNEL #1
P1
J14
2W INPUT AND OUTPUT
4W OUTPUT
J8
P2
R 1,200
R6 47K
R5 4,700
R7 22K
K3 SEND
K4 RECEIVE
FROM B+ TBIA-12
FROM B+ TBIA-11
RINGING B+ FROM TBIA-14 EGPFR
TBIA-2
TBIA-1
20CPS
CHANNEL 1
CHANNEL 2
MODEM
MOUNTING RACK
REMOTE KEYING UNIT
CHANNEL 1
CHANNEL 2

NOTES:

1. CHANNEL 2 REMOTE KEYING UNIT IS WIRED EXACTLY AS CHANNEL 1 REMOTE KEYING UNIT
2. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS

TM 5091-629

Figure 186. Remote keying circuit, remote keying operation.

the east operator talks, the voice signal is transmitted through the radio-relay system by modulation of the inserted pulse and thus modulates the distant vhf transmitter signal. Assuming the mobile unit is within range of the vhf transmitter, the vhf signal will be received and heard by the mobile unit operator.

(*b*) To reply, the mobile unit operator transmits a modulated vhf signal, which is picked up by the fixed vhf receiver at the west terminal. The receipt of this signal causes a squelch relay to operate. The contacts of this relay are connected to the REMOTE KEYING IN binding posts of the multiplexer set. When the squelch relay shorts these contacts, it causes the proper channel pulse to be inserted in the output pulse train. Consequently, when the mobile unit operator talks, his speech signal is received by the vhf receiver at the west multiplex location, where it is connected to the multiplexer set and modulates the inserted pulse. The modulated pulse train is transmitted to the east terminal through the radio-relay system. There it is demultiplexed and demodulated by the multiplexer set east terminal and the audio signal fed through the normal binding posts to the original east operator.

(2) *Between two mobile units* (fig. 25). To talk from one mobile unit to another mobile unit by way of two fixed vhf stations at two different multiplex locations, it is only necessary for either mobile unit operator to operate exactly as if he were talking to another mobile unit. The signal is carried through the multiplexer set and radio-relay system exactly as described in subparagraph (1) (*a*) and (*b*) above, except that there is a vhf station at both locations.

c. Internal Multiplexer Remote Keying Operation.

(1) *General.*

(*a*) The remote keying facility allows remote keying on either or both channel 1 and channel 2. The operation is identical on both channels; therefore only one case will be discussed.

(*b*) Remote keying is accomplished by removing the plug-in unit, rotating it 180°, and reinserting it (fig. 9). When inserted in the proper polarity, this unit has the function of blanking or inserting the pulse as required for sending, or of being operated in receiving by the pulse that has been blanked or inserted.

(*c*) Audio connections remain the same on the remotely keyed channels as on all other channels.

(*d*) Either two- or four-wire connections may be used at a terminal only. Only party-line operation is available at a repeater, and this terminates in a two-wire connection.

(*e*) Subparagraph *c*(2) and (3) below gives a detailed description of the operation of remote keying in a multiplexer set. This is independent of occasions when it is used with two mobile units, or with a single mobile unit, with an operator located near a multiplex location. The description therefore applies to either case. Figure 265 is a complete schematic diagram of the remote keying unit. The relays in the remote keying unit are still a part of the circuit in NORMAL OPERATION, although they have no function except to connect B+ to V2 in the modem (fig. 137).

(2) *Sending into a multiplexer set* (fig. 138). A short circuit may be placed across the REMOTE KEYING IN terminals E12 and E13 (located on the multiplexer subassembly) by

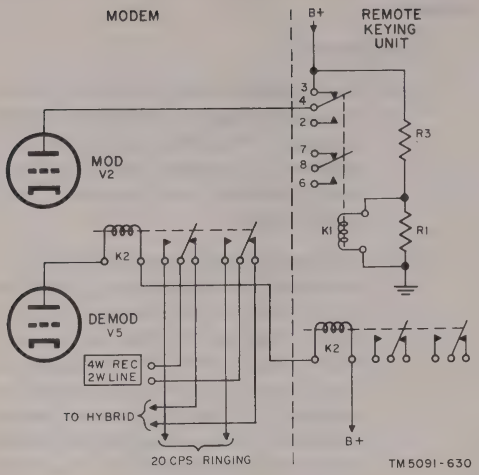


Figure 137. Remote keying, normal operation, simplified schematic.

either a local operator with a keying switch or as the result of a vhf receiver that operates a squelch relay to do the same thing. The following actions occur:

(*a*) Relay K1 operates, because one end of its coil is keyed to ground and the other end is returned to the bleeder from B+ (consisting of R1 and R3). Relay contacts 6 and 8 of K1 close, which causes relay K2 to remain operated by the coil being returned from B+ through R2 to ground. Relay contacts 2 and 4 of relay K1 make contact, returning the plate of modulator V2 to B+. This energizes V2 and inserts the pulse.

(*b*) Relay K2, which was previously returned through contacts 7 and 8 of relay K1 through the coil of relay K2 to B+, is now de-energized, and as a result the hybrid transformer is disconnected from terminating resistors R4 and R8 and is connected to the two-wire terminals to complete the voice circuit.

(3) *Receiving from a multiplexer set* (fig. 138). The correct channel pulse on the video signal fed from the r-f equipment into the multiplexer set causes V5 to be cut off, thus releasing relay K2. The following actions occur:

(*a*) The output of the hybrid is connected to the output terminals, which are disconnected from terminating resistors R4 and R8.

(*b*) Remote keying relay K2 is in series with modem relay K2 and therefore also releases, to connect contacts 3 and 4 (of remote keying K2) and to place a short circuit across E16 and E17, the REMOTE KEYING OUT binding posts. This operates the associated vhf transmitter.

133. Alarm Circuit

(fig. 138 and 139)

a. General. If any part of the circuit fails the alarm circuit operates by monitoring points in the circuit. For example, the positive pulse train reshaper is monitored for output, input, and noise. In general, failure of any one of the above listed signals will cause visible and audible alarm signals. This is done by having these signals control the input to the alarm operating relays through their respective amplifiers.

b. Output. The pulse train at the grid of the last stage in the positive pulse train reshaper is monitored by monitor amplifier V16A (fig. 139). The pulse train available across grid return resistor R92 is about 14 volts negative (A, fig. 139). The voltage developed across plate load resistor R93 is 12.3 volts peak to peak (B, fig. 139). This voltage is fed to clamper tube V18B and rectifier V17A by coupling capacitor C51. This results in a 12.3-volt positive d-c voltage being built up across cathode load resistor R95. This +12.3 voltage is applied to the grid of relay control amplifier V15B. Therefore, the relay control tube conducts and causes the bypass and alarm relays K1 and K2 to be held in the operate condition. If any of the tubes fail prior to the point monitored in the positive pulse train reshaper, the

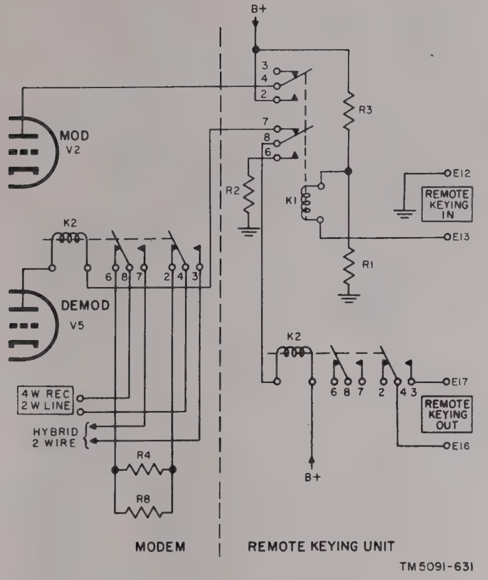

B+
3
4
2
R3
7
8
6
MOD
V2
R2
K1
E12
REMOTE KEYING IN
E13
K2
6 8 7 2 4 3
R1
DEMOD
V5
K2
E17
6 8 7 2 4 3
REMOTE KEYING OUT
4 W REC
2 W LINE
HYBRID 2 WIRE
E16
R4
B+
R8
MODEM
REMOTE KEYING UNIT
TM5091-631

Figure 138. Remote keying, remote keying operation, simplified schematic diagram.

d-c voltage at the grid of the relay control amplifier will decrease, causing plate current to decrease, which in turn releases the bypass and alarm relays. This causes an audible and visual alarm to operate, bypassing the reshaper through a 6-db pad and disconnecting the 20-cycle ringing voltage from the local drop channels. Relay control tube V15B is biased by the voltage divider network of R96 and R97 so that under *no signal* conditions tube V15 will not have sufficient plate current to operate relays K1 and K2. If the very last stage of the positive pulse train reshaper fails, it will not be indicated to the alarm relays by this path. However, if the filament of the last stage should burn out, its grid would rise to about +75 volts. This would result in zero bias applied to damper V16B through R63, thereby resulting in sufficient conduction to load output pulse train monitor amplifier V16A to a point where V15B will become cutoff and the alarm will operate.

c. Input (fig.140).

(1) With normal signal input voltage (.5 volt peak) the negative d-c voltage available at the plate of peak detector V8 in the reshaping clipping circuit is sufficient to hold a 12AT7WA in the cutoff condition.

(2) When the input voltage decreases to .1 volt peak, the negative d-c voltage obtained from the diode bias circuit is about –3 volts. This voltage is applied to the grid of damper V16B, which is in parallel with the output pulse train amplifier. The –3-volt bias on V16B allows sufficient conduction of this tube to decrease the gain of monitor amplifier V16A so that the voltage applied to the grid of relay control V15B will decrease the current in V15B to less than 1 milliampere which is the relay release current. Therefore, the reshaper will be bypassed, ringing will be disconnected, and the audible and visual alarms will be energized.

d. Noise. The demodulator MODEM PULSE TRAIN OUTPUT at J7 is monitored for detection of large noise inputs. With a normal pulse train input, the frequency spectrum of the wave form at this point will contain in-

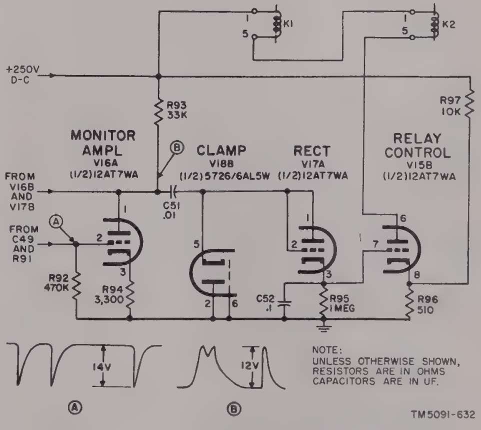

K1
K2
1
5
+250V D-C
R93 33K
R97 10K
MONITOR AMPL V16A (1/2)12AT7WA
Ⓑ
CLAMP V18B (1/2)5726/6AL5W
RECT V17A (1/2)12AT7WA
RELAY CONTROL V15B (1/2)12AT7WA
FROM V16B AND V17B
C51 .01
FROM C49 AND R91
Ⓐ
R92 470K
R94 3,300
C52 .1
R95 1MEG
R96 510
14V
12V
Ⓐ
Ⓑ
NOTE: UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS CAPACITORS ARE IN UF.
TM5091-632

Figure 139. Alarm circuit V16A, V18B, V17A and V15B.

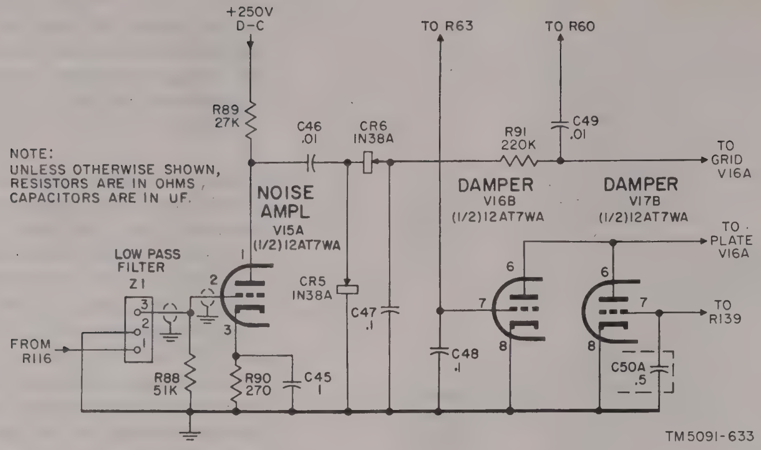

+250V
D-C
TO R63
TO R60
R89
27K
C46
.01
CR6
IN38A
R91
220K
C49
.01
TO
GRID
V16A
NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS,
CAPACITORS ARE IN UF.
NOISE
AMPL
V15A
(1/2)12AT7WA
DAMPER
V16B
(1/2)12AT7WA
DAMPER
V17B
(1/2)12AT7WA
TO
PLATE
V16A
LOW PASS
FILTER
Z1
CR5
IN38A
C47
.1
TO
R139
FROM
R116
C48
.1
C50A
.5
R88
51K
R90
270
C45
1
TM5091-633

Figure 140. Alarm circuit V15A, V16B, and V17B.

significant components below 8 kc. However, if an r-f transmitter in the link fails, the receiver at the local station will put a large noise signal into the restorer. This noise signal will contain appreciable frequency components below 4 kc. These components will be available with large amplitude at the noise monitored point. This signal is fed into a 4-kc low-pass filter, Z1 (fig. 140), and is amplified by V15A. Capacitor C49 is the input coupling capacitor for V15A. The filter output is developed across grid return resistor R88 and applied to the grid. Resistor R90 and capacitor C45 form the biasing network for V15A. The voltage developed across plate load resistor R89 is coupled through coupling capacitor C46 and applied to two germanium rectifiers CR5 and CR6, which results in a large negative voltage when high noise is present, and 0 volt when the normal pulse train condition is restored. When the large negative voltage is available, it is applied to the grid of output pulse train monitor amplifier V16A and cuts off this tube, thereby resulting in 0 volts applied to the grid of V15B, cutting off the tubes and de-energizing the relays.

e. Marker Separator. When the marker separator and gate shaping stages are operating normally, a negative voltage of approximately 30 volts is available at the grid of the multiplexer gate driver. This voltage is used to hold damper V17B at cutoff. This is in parallel with the output pulse train monitor amplifier. If any of the tubes in the marker separator and gate shaping section should fail, the voltage applied to the grid of damper V16B will be 0 volt. This will cause sufficient conduction of V17B to decrease the gain of monitor amplifier V16A to the point where relay control V15B will be cut off. Therefore, if any of the tubes in this section fail, the 20-cycle ringing will be disconnected from the local drop channels and audible and visual alarms will be energized. In addition, the pulse train reshaper will be bypassed, because the 20-cycle ringing disconnect relay and bypass relay are operated by the same tube.

Section III. POWER SUPPLIES

134. Voltage Regulator
(fig. 141)

a. General. The voltage regulator is an electromechanical unit. It consists of buck-boost transformer T4 in series with the applied power, a bridge across which is impressed any error signal, gas tubes to select the direction of the error, and reversible motor B1, controlled by the gas tubes that operate variable transformer T3. Transformer T3 controls primary of the buck-boost unit 23. A buck-boost transformer has a secondary in series with the voltage source, which causes the output voltage to subtract (buck) or add (boost) to the source voltage.

b. Power Circuit (fig. 142). The unregulated a-c input is applied to either J2 (230V AC POWER INPUT) or J4 (115V AC POWER INPUT), depending on the input voltage. The +230V circuit breakers, CB1 and CB2, protect the input from J2, while 115V circuit breakers CB3 and CB4 protect the input from J4. The 115-volt a-c output of T5 is applied to terminals 1 and 2 of variable autotransformer T3. The corrective voltage output of T3 appears between terminals 3 and 4. Terminal 4 connects to the motor-driven brush of the brush assembly of T3. The output from terminals 3 and 4 represents the corrective electromotive force (emf) for the primary of series compensating buck-boost transformer T4. The secondary of T4 (terminals X1 and X2) then gives the proper series compensating voltage so that the output of the power circuit is maintained at a constant voltage of 115 volts ac. This 115-volt a-c output appears across terminals D and E of AC POWER OUTPUT jack J3. Fuse F3 prevents damage to the sliding contacts. Pilot light I 1 indicates the presence of output voltage.

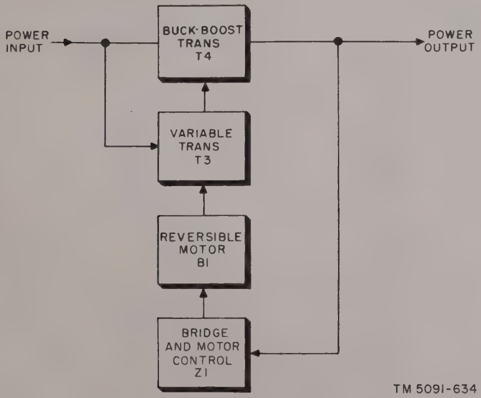


Figure 141. Voltage Regulator CN–236/G, block diagram.

c. Control Circuit (fig. 143).

(1) *General operation.* The control circuit maintains a regulated a-c output by correctly positioning the brush of variable autotransformer T3. This control is accomplished as follows: an a-c bridge gives an output a-c voltage proportional to any change in the monitored power circuit output. This bridge-detected error voltage then causes one of the thyratrons to fire, energizing its associated relay. This, in turn, applies line voltage to the split-phase motor; the motor then rotates to correct for either the rise or fall of the power circuit output voltage. When the brush moves to the correct position, the drive motor stops. The system is then in equilibrium, awaiting another rise or fall in the regulated output voltage.

(2) *Detailed operation and characteristics.*

(*a*) *Control circuit input transformer T1.* The secondary transformer T1 supplies a balanced input to the a-c bridge from terminals 3 and 5 (with terminal 4 as center tap) ; 12.6 volts ac between terminals 3 and 6 for the series connected filaments of thyratrons V1 and V2; and the same a-c source given above but for the fixed d-c bias circuit for the thyratrons.

(*b*) *A-c bridge.* The balanced secondary windings of T1 serve as two arms of the a-c bridge and also supply

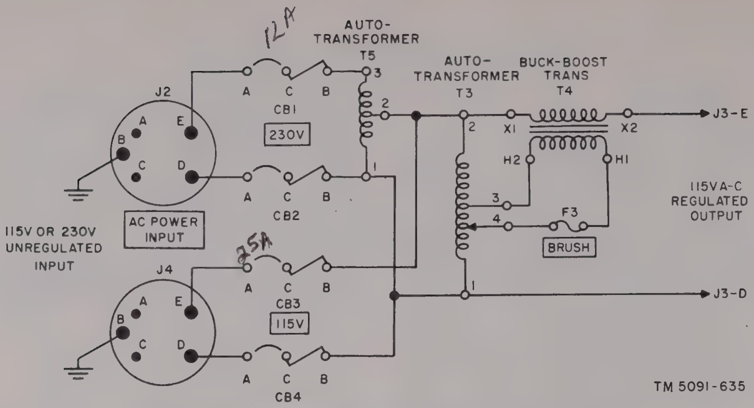
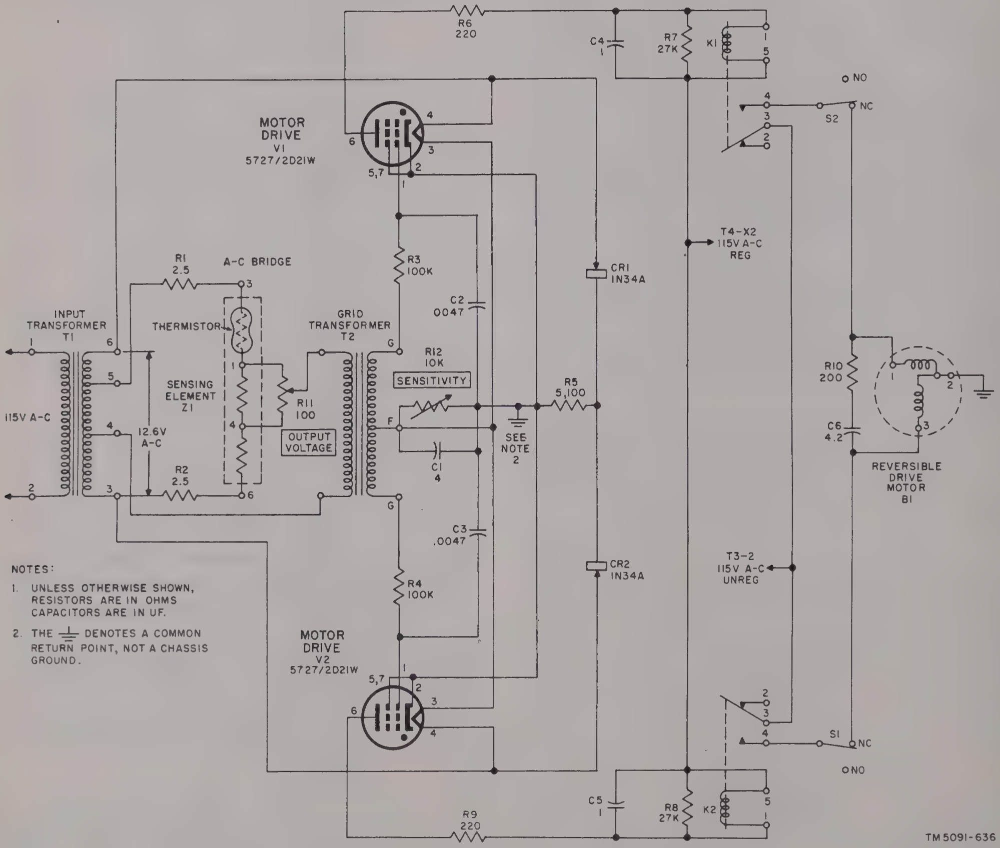

12A
AUTO-TRANSFORMER T5
3
2
1
AUTO-TRANSFORMER T3
BUCK-BOOST TRANS T4
J2
A
B
C
D
E
A C B
CB1
230V
A C B
CB2
X1
X2
H2
H1
F3
BRUSH
J3-E
J3-D
115VA-C REGULATED OUTPUT
AC POWER INPUT
115V OR 230V UNREGULATED INPUT
25A
J4
A C B
CB3
115V
A C B
CB4
TM 5091-635

Figure 142. Voltage Regulator CN–236/G, power circuit.


R6
220
C4
1
R7
27K
K1
1
5
O NO
4
3
2
S2
NC
MOTOR DRIVE
V1
5727/2D21W
6
4
3
5,7
2
1
T4-X2
115V A-C
REG
R3
100K
CR1
1N34A
R1
2.5
A-C BRIDGE
3
C2
.0047
INPUT TRANSFORMER
T1
THERMISTOR
GRID TRANSFORMER
T2
1
6
G
R12
10K
SENSITIVITY
R10
200
5
SENSING ELEMENT
Z1
R11
100
R5
5,100
115V A-C
4
12.6V A-C
OUTPUT VOLTAGE
F
SEE NOTE 2
C6
4.2
C1
4
REVERSIBLE DRIVE MOTOR
B1
2
R2
2.5
6
G
C3
.0047
T3-2
115V A-C
UNREG
CR2
1N34A
R4
100K
MOTOR DRIVE
V2
5727/2D21W
5,7
1
2
3
6
4
2
3
4
S1
NC
O NO
C5
1
R8
27K
K2
5
1
R9
220
TM5091-636

NOTES:

1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS CAPACITORS ARE IN UF.
2. THE ⏚ DENOTES A COMMON RETURN POINT, NOT A CHASSIS GROUND.

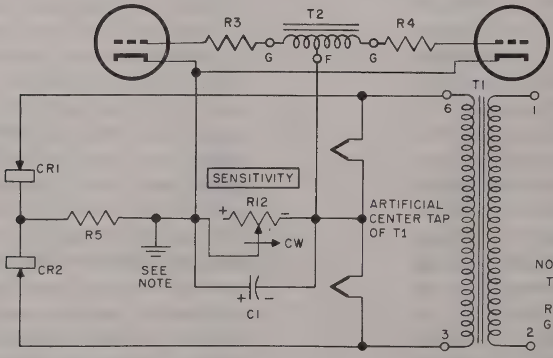
Figure 143. Voltage Regulator CN–236/G, control circuit.

the driving voltage for the bridge. The center tap (4) of T1 then serves as one bridge output terminal. The opposite two arms consist of the thermistor, fixed resistors, and potentiometer R11, the variable arm of which serves as the adjustable center tap, and other bridge output terminal. The resistors shown within the dotted rectangle of figure 143 comprise inclosed sensing unit Z1. With the proper voltage applied to input transformer T1, equal but opposite voltages will be developed across the input arms of the bridge. This will result in a current flow through resistor R1, through the thermistor, through the OUTPUT VOLTAGE control arm, and through the primary of grid transformer T2 to terminal 4 of the input transformer. At the same time, an equal current will be flowing from terminal 4 through the grid transformer to the arm of R11 through the lower resistor of Z1 through R2 to terminal 3 of the input transformer. The action described above results in a zero voltage in the secondary of T2, because currents in the primary are equal but opposite. If the input a-c voltage should increase, the current through the bridge would also increase. Any increase in current flowing through the thermistor bead would cause an increase in its resistance, thus unbalancing the bridge. Grid transformer T2 will then receive its input voltage from the 3 to 4 winding of transformer T1. This will cause the motor to rotate so that the applied a-c voltage decreases. If the input voltage should decrease, the current flowing through the bridge will also decrease. This will cause the resistance of the thermistor to decrease. The grid transformer will now receive its voltage from the 4 to 5 winding of transformer T1. This causes the motor to rotate in the opposite direction, increasing the applied a-c voltage.

(*c*) *Push-pull thyratrons.* The output of the bridge is applied to the primary of transformer T1. Opposite ends of the secondary of T1 are connected to the grids of V1 and V2 by the center-tapped secondary of grid transformer T2 (fig. 144). The signals applied to two thyratron grids are always out of phase with each other. One of the two signals will be in phase with V1 a-c plate voltage and out of phase with V2 a-c plate voltage. For this reason, only one tube will conduct for any given error signal. When the phase of the error signal is reversed, the other tube will conduct. Germanium diodes CR1 and CR2 are the rectifiers biasing the thyratrons. The common filament connection is used as an artificial center tap of T1. In the normal (no error) signal condition, both thyratrons are held beyond cutoff by the fixed bias developed across potentiometer R12, connected between cathode and grid of the two thyratrons. The bias voltage may be varied by adjusting R12. With the SENSITIVITY CONTROL turned clockwise, the bias voltage will be near zero because the resistance of R12 will be almost zero. In this condition, the slightest error voltage will be detected and the servo motor will accordingly be required to operate more frequently to maintain the output a-c voltage constant. Any higher sensitivity requirement will prove a detriment, for the system will go into oscillation or *hunting.* Hunting displays itself as a violent gear chatter, as a result of the rapid reversals of the drive motor. Therefore, the proper adjustment of R12 involves increasing the sensitivity until chatter occurs and then turning it back slightly. The motor will then remain relatively quiet, only moving occasionally to follow input line fluctuations. The other extreme involves adjusting R12 for full resistance, thus giving a maximum negative bias. A large error signal is then necessary to cause thyratron conduction, relay operation, and correction of a-c voltage error. Potentiometer R11 controls the voltage applied to the thyratron grids. By varying the voltage applied to the grids, a new reference voltage is established. Varying this control adjusts the output voltage from the voltage regulator to the power supply.

(*d*) *Motor circuit.* To aid in the discussion of the motor circuit, assume that a rise occurs in the output voltage. The bridge circuit detects an error voltage. This error voltage will then appear on one grid out of phase with the regulated a-c common plate voltage and in phase with the plate for the grid of the other thyratron. The tube which has both the grid and plate driven positively will fire when the electrode voltages are sufficiently positive for breakdown. The relay associated with this tube will then be energized. The unregulated a-c input will be applied to the split-phase motor, directly across one motor winding and in series with C6 and R10 across the other motor winding. This will result in a rotation of the motor shaft (and thus the motor-coupled autotransformer brush (T3)) to compensate for the rise in output. Capacitor C6 and resistor R10 supply the necessary 90° phase shift between the voltages across the two motor windings. If any overshoot occurs, the first tube will extinguish, de-energizing its relay and the other tube will fire, energizing its relay. The autotransformer brush will be driven in the reverse direction because R10 and C6 will be in series with the other motor winding, giving a change in the direction of rotation. Also included in the motor circuit is end-stop protection. Microswitches S1 and S2 are actuated when the end-stops of the brush assembly are reached. Thus, when either extreme is reached, the switch associated with it opens. This disconnects the motor and prevents any further attempt on the part of the motor to operate in the blocked rotor direction.

(*e*) *Regulated output.* Output is taken from pins D and E of AC POWER OUTPUT jack J3. Pilot light I 1



NOTE:
THE ⊥ DENOTES A COMMON RETURN POINT, NOT A CHASSIS GROUND.

TM 5091-637

Figure 144. Voltage Regulator CN–236/G, filament and full-wave rectifier bias arrangement.

indicates that output power is present. Fuse F2 is in series with the pilot light.

135. Filament Supply (Multiplexer Subassembly MX–1442/TC)
(fig. 264)

a. The filament supply provides filament power to the entire multiplexer set. It contains the alarm and indicator circuits and blower B1. B+ voltage is brought into this unit through +250V INPUT jack J5, pins B and C, and ac is brought in through 115V AC INPUT jack J6, pins C and D. Indicator lamp I 2 on the filament supply unit (FILAMENT ON) is energized when power is applied. Fuses F1 through F4 are in series with the B+ voltage applied to the modems. The 100-microfarad (uf) filter capacitors C1 through C4 are connected between the modem side of these fuses and ground to provide additional filtering of the B+ voltage. The B+ voltage applied to the video restorer is taken from terminal 8 of terminal board TB4A. Filter capacitor C5 is connected between this point and ground.

b. Filament supply terminals are:

(1) Terminals 9 and 10 of TB3A, which provide ringing current by connecting the 20-cps generator to each of the modems through pins E and F of J11.

(2) Terminals 7 and 8 of TB2A, which connect the modems with the test pair from the audio test set through pins C and D of J11.

(3) Terminals 5 and 6 of TB3A, which connect the control monitor to the channel 1 order-wire circuit through pins A and B of J11.

c. A regulated 115-volt, 60-cps a-c voltage is applied across the primaries of filament transformers T1 and T2 through 2-ampere fuses F5, F6, F7, and F8. The secondary of transformers T1 and T2 provides 6.3-volt a-c filament power to the video restorer and the modems.

d. Application of 115 volts ac to the filament supply energizes blower motor B1 (a 115-volt, 60-cps, split-phase induction motor) and lights FILAMENT ON indicator lamp I 2. Four convenience UTILITY POWER outlets, J7 through J10, are located in the filament supply. Two outlets are on the front panel and the two others are on the rear panel. Lamp I 1 is a neon light that indicates the presence of 250 volts dc. Lamp I 4 indicates operation of the alarm. Connectors J1 and J2 are the receptacles for the channel 2 remote keying plug-in units, and J3 and J4 are the receptacles for the channel 1 remote keying plug-in units. Connector J11 (TEST PAIR) is the receptacle for the channel 1 order wire and modem test pair. Switch S1 is the audible alarm disconnect pushbutton switch. Contacts E5 through E10 are gaps used for surge protection. Relays K1 and K2 are used to stop ringing.

136. Power Supply PP–691/G

The power supply consists of power transformer T1, the output of which is rectified by selenium rectifiers CR1 and CR2. The d-c output then is filtered by chokes L1 and L2 and capacitors C1 through C8. The d-c output then is taken from the output receptacles. The four principal sections of the power supply are shown in the block diagram in figure 145. The power supply for the multiplexer group supplies the +250-volt plate supply for all components except the oscilloscope and test set. Refer to figure 269 for the power supply schematic diagram.

a. The 115-volt a-c input ±1 volt, 47.5 to 63 cps, is applied to AC POWER INPUT connector J1, pins D and E. Ganged circuit breakers CB1 and CB2 (FILAMENT) apply the 115 volts to the filament chassis through connector J6. When the circuit breaker combination is operated, 250V ON indicator lamp I 2 lights to show that power has been applied. With the application of power, 115 volts ac is applied to 115V AC OUTPUT jacks J4 and J5, the oscilloscope, and the audio test set outlets. Four convenience outlets, J7, J8, J9, and J10, UTILITY POWER, are provided on the power supply chassis. Power to these outlets is applied through 5-ampere fuses F1 and F2.

b. Operation of the AC POWER INPUT switch, CB1 and CB2, applies primary power to power supply transformer T1 through

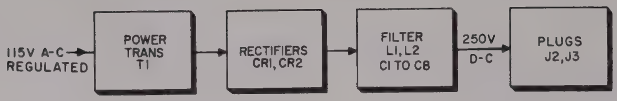


Figure 145. Power Supply PP–691/G, block diagram.

+250V circuit breaker CB3 and to +250V lamp I 1. The secondary of T2 supplies 339-volts root mean square (rms) to bridge rectifiers CR1 and CR2. The dc is then fed to a choke input filter consisting of inductor L1 and L2, filter capacitors C1 to C4 in parallel, and C5 to C8 in parallel, with bleeder resistor R1 across the d-c output. The 250-volt d-c output is connected to J2, pins B and C, and to 250V-115V AC OUTPUT jack J3, pins A and B.

Section IV. TEST EQUIPMENT

137. Oscilloscope OS–25/G, Block Diagram

a. Oscilloscope OS–25/G consists of five sections (fig. 110 and 146). These sections consist of a vertical deflection and calibration section with a bandwidth from 30 cps to 5 mc; a horizontal sweep generator (amplifier system) variable in speed from 5 milliseconds per cm to .5 microsecond per cm; a timing-marker generator to produce 5.2-microsecond timing pips; a power supply with various voltage supplies; and a cathode-ray tube.

b. The vertical deflection section amplifies or attenuates the signal being observed. It consists of an attenuator, vertical input amplifier V12, cathode follower V13, and push-pull vertical output V14 and V15.

c. The horizontal deflection system which provides the voltage required to deflect the beam across the crt is the most complex of the oscilloscope circuits. The stage-by-stage function of the horizontal system is described in paragraph 141. The horizontal system contains the following:

(1) The 8-kc amplifier, triggering, and synchronizing stages, tubes V16A through V19A.

(2) The multivibrator, V20 and V21, provides the horizontal deflection timing signal, and with buffer amplifier V27B and blanking restorer V19B, it provides the unblanking pulse to the crt.

(3) Sweep generator and control tubes V22 and V23 provide the regulated sawtooth voltage required for the horizontal deflection of the beam.

(4) D-c restorer V24 assures horizontal stability by returning the circuit to its original d-c state after each horizontal sweep.

(5) Final horizontal output amplifiers V25 and V26 provide the necessary amplification to obtain the 350 volts required to deflect the beam across the face of the crt.

d. The timing marker circuit provides pulses separated by 5.2 usec. It is sometimes called the timing-pip generator and consists of 8-kc amplifiers V27A and V28A, synchronizing pulse generator V28B, discriminator rectifier V29, reactance modulator and 192-kc oscillator V30, 192-kc amplifier V31A, and differentiating shaper V31B.

e. The oscilloscope power supply produces six d-c voltages. These are +450 volts regulated, +225 volts regulated, –1,500 volts, –600 volts, –140 volts, and +1,800 volts. Tubes V1 and V2 provide +1,800 volts and –1,500 volts; V3, V4, and V5 provide +450 volts; V6, V7, V9, and V10 provide +225 volts; and V8 provides –140 volts.

f. The crt section contains control circuits for proper operation of the tube.

g. The technical characteristics of the oscilloscope are as follows:

Vertical amplifier bandwidth	30 cps to 5 mc.
Vertical sensitivity	.4 volt per cm (maximum).
Vertical attenuation	Variable over a range of 1, 2, 10, and 100:1.
Probe:	
Input impedance	10 megohms in parallel with 12 uuf.
Attenuation	10:1.
Horizontal sweep speed	5 milliseconds to .5 microsecond per cm.
Horizontal sweep synchronization	External or internal.
Synchronizing trigger requirements	.5 volt minimum; 50 volts maximum (a minimum of .1 usec duration).
Accelerating potential	3,300 volts.
Input power requirements	270 watts, 105 to 125 volts, 50 to 60 cps.
Timing marker	5.2 microseconds (variable over a range of 7 usec).

Note. Means are provided to calibrate the vertical sensitivity of the oscilloscope, through substitution of a square wave of power line frequency for the wave form applied to the vertical input terminals. By adjusting the height of this wave form to correspond to the deflection to be measured, the vertical sensitivity of the particular setting of the gain controls can be obtained.

138. Oscilloscope Cathode-ray Tube Circuit

The oscilloscope uses a type 5CP1A cathode-ray tube, V32. This is a 5-inch tube with electrostatic focus and deflection. It uses post-deflection intensification; the electron beam is accelerated before and after deflection so that lower voltages can be used for deflection and provides good viewing intensity.

a. The –1,500-volt power supply is applied to the cathode of tube V32 through 500,000-ohm intensity control R186. Thus, the first grid, which is returned to the arm of this control through 1.5-megohm resistor R184, has a potential applied to it which is negative with respect to the cathode, and which can be varied to control the intensity of the electron beam. Potentiometer R187 controls pin 5, the first anode potential, which also is derived from the –1,500-volt supply and is at a positive potential with respect to the cathode.

b. The second anode potential is adjusted by means of an adjustment on the front panel (ASTIG). This controls the voltage at the arm of potentiometer R174 and insures that equal focus is maintained in both the horizontal and vertical axis. Vertical positioning of the trace is accomplished with a dual potentiometer, R180, connected between the +225- and –140-volt supplies. Turning this control increases the potential applied to one vertical deflection plate of the crt and decreases the other. The distribution of voltage along the beam axis of the crt is unchanged, and no change of the focusing controls is required to maintain proper focusing.

c. Resistors R176 and R177 act as voltage dividers in series with the vertical positioning potentiometers. Resistors R179 and R181 are decoupling resistors, and capacitors C87 and C88 are decoupling capacitors.

d. Unblanking of the trace is accomplished by an unblanking pulse applied to the grid of the crt.

e. Plus 1,800 volts is fed directly to the final anode of the crt from the oscilloscope high-voltage power supply.

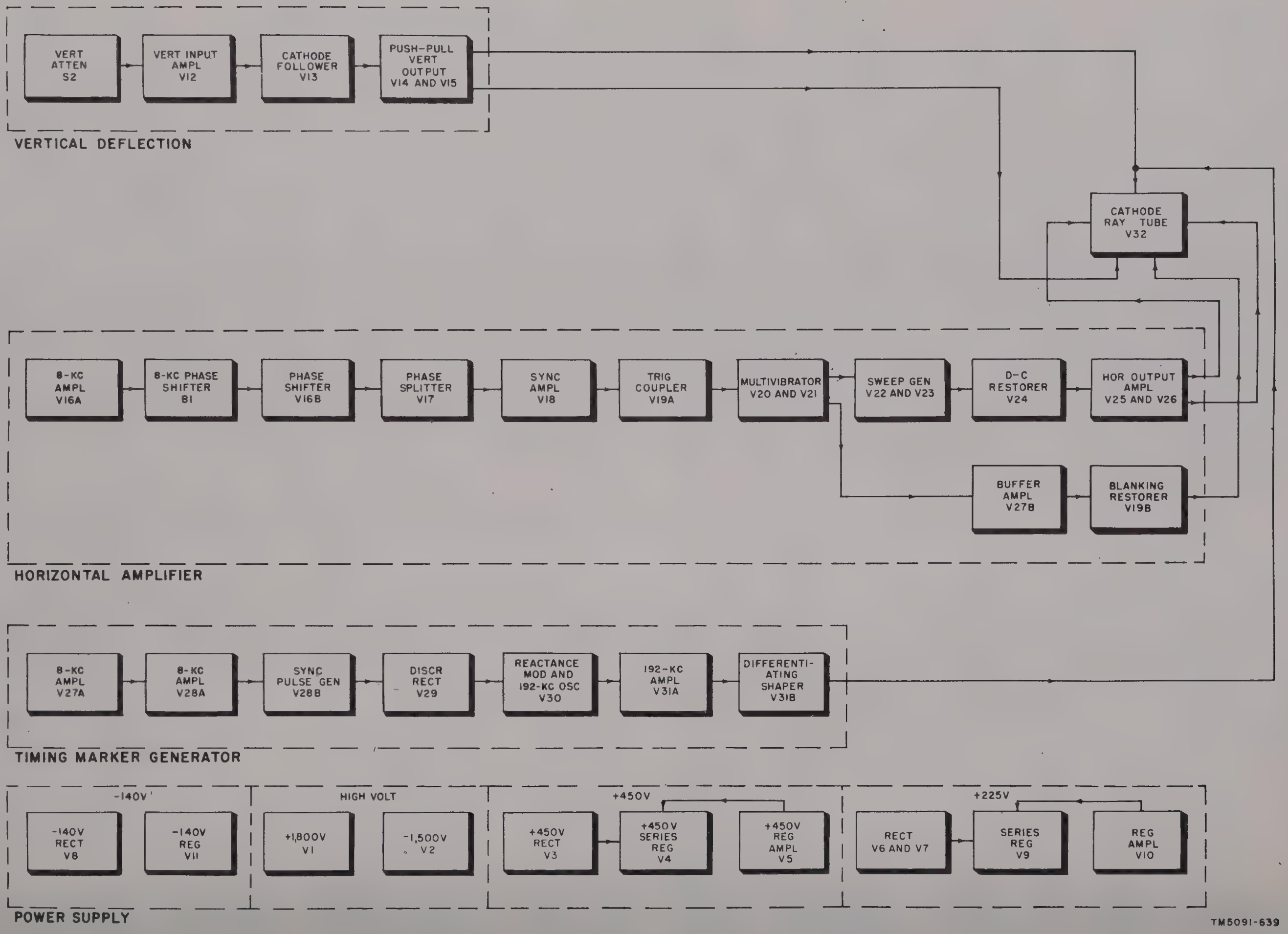
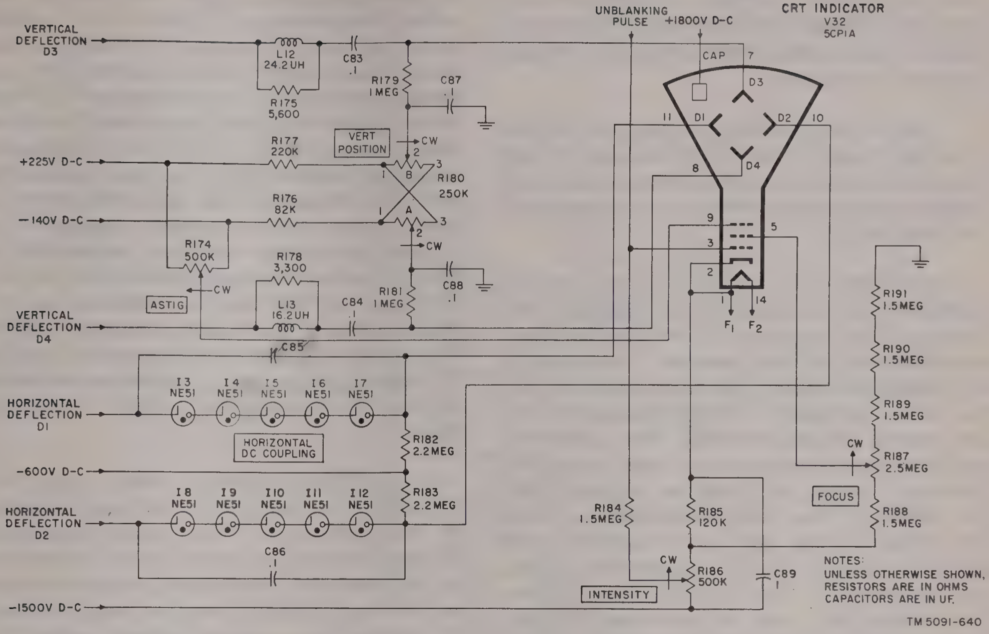

VERT ATTEN S2
VERT INPUT AMPL V12
CATHODE FOLLOWER V13
PUSH-PULL VERT OUTPUT V14 AND V15
VERTICAL DEFLECTION
CATHODE RAY TUBE V32
8-KC AMPL V16A
8-KC PHASE SHIFTER B1
PHASE SHIFTER V16B
PHASE SPLITTER V17
SYNC AMPL V18
TRIG COUPLER V19A
MULTIVIBRATOR V20 AND V21
SWEEP GEN V22 AND V23
D-C RESTORER V24
HOR OUTPUT AMPL V25 AND V26
BUFFER AMPL V27B
BLANKING RESTORER V19B
HORIZONTAL AMPLIFIER
8-KC AMPL V27A
8-KC AMPL V28A
SYNC PULSE GEN V28B
DISCR RECT V29
REACTANCE MOD AND 192-KC OSC V30
192-KC AMPL V31A
DIFFERENTIATING SHAPER V31B
TIMING MARKER GENERATOR
-140V
-140V RECT V8
-140V REG V11
HIGH VOLT
+1,800V V1
-1,500V V2
+450V
+450V RECT V3
+450V SERIES REG V4
+450V REG AMPL V5
+225V
RECT V6 AND V7
SERIES REG V9
REG AMPL V10
POWER SUPPLY
TM5091-639

Figure 146. Oscilloscope OS–25/G, over-all block diagram.



VERTICAL DEFLECTION D3
L12 24.2 UH
R175 5,600
C83 .1
R179 1 MEG
C87 .1
UNBLANKING PULSE
+1800V D-C
CRT INDICATOR V32 5CP1A
CAP
7
D3
11
D1
D2
10
D4
8
9
5
3
2
1
14
F1
F2
VERT POSITION
CW
2
3
1
B
R180 250K
A
+225V D-C
R177 220K
-140V D-C
R176 82K
R174 500K
R178 3,300
C88 .1
R181 1 MEG
C84 .1
L13 16.2 UH
ASTIG
VERTICAL DEFLECTION D4
C85
HORIZONTAL DEFLECTION D1
I3 NE51
I4 NE51
I5 NE51
I6 NE51
I7 NE51
HORIZONTAL DC COUPLING
R182 2.2MEG
-600V D-C
I8 NE51
I9 NE51
I10 NE51
I11 NE51
I12 NE51
R183 2.2MEG
HORIZONTAL DEFLECTION D2
C86 .1
-1500V D-C
R184 1.5MEG
R185 120K
R186 500K
INTENSITY
C89 .1
R191 1.5MEG
R190 1.5MEG
R189 1.5MEG
R187 2.5MEG
FOCUS
R188 1.5MEG
NOTES:
UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS CAPACITORS ARE IN UF.
TM 5091-640

Figure 147. Cathode-ray tube circuits.

f. Vertical deflection signals are fed through R175 in parallel with L12, and R178 in parallel with L13, then through C83 and C84. This network isolates the supply voltage from the signal voltages.

g. Horizontal deflection voltages are coupled to the crt plates through capacitors C85 and C86. Capacitor C85 is in parallel with neon lamps I 3 through I 7. Capacitor C86 is in parallel with neon lamps I 8 through I 12. The neon lamps maintain the voltage across the capacitors constant and prevent defocusing. Resistors R182 and R183 return the plates to –600 volts.

139. Oscilloscope Power Supply Circuits
(fig. 148)

The oscilloscope contains power supplies that produce –1,500 and –600 volts dc, +1,800 volts dc, +450 volts regulated, +225 volts regulated, and –140 volts.

a. The a-c input is applied through switch S1, indicator pilot light I 1, and through fuse F1 to transformer T1 and through fuse F2 to transformer T2.

b. Transformer T1 produces the following voltages: terminals 5 and 6 provide 6.3 volts ac for the crt filament, terminals 10 and 11 provide 2.5 volts ac for the filament of V2 (–1,500-volt rectifier), terminals 3 and 4 furnish 2.5 volts ac for the filament of V1 (+1,800-volt rectifier), 1,400 volts ac for both high voltages (–1,500- and +1,800-volt rectifiers), 520 volts ac to the diode-connected plates of V3, terminals 14 and 16 supply 6.3 volts for the filaments in the horizontal and vertical circuits.

c. Transformer T2 produces 6.3 volts ac for the filament of V5, 640 volts center-tapped to ground for the +225-volt supply, 5 volts ac for the filaments of tubes V6 and V7, 6.3 volts ac for the filament of V8, and 6.3 volts ac for horizontal sweep control tube V23.

d. The –1,500-volt supply (fig. 149) is rectified by V2 and filtered by resistor R6 and capacitors C2 and C3. The –600 volts is obtained from the same rectifier tube but dropped through R7 and R8.

e. The +1,800-volt supply (fig. 150) is rectified by V1 and is filtered by resistor R5 and capacitor C1. Resistors R1 through R4 act as a bleeder circuit and provide a discharge path for capacitor C1.

f. The +450-volt rectifier, V3 (fig. 151), is operated as a diode because both plates are tied together. The tube current is limited by resistors R192 and R193 in parallel. The output is regulated electronically by series regulator V4, the series resistance of which changes to keep the output voltage constant. The +225-volt regulated supply is used as a reference for the +450-volt supply and must be adjusted first. The output of the +450-volt supply is across the voltage divider R15, R16, and R17. The grid of regulator tube V5 is connected to a tap on potentiometer R16 through current limiting resistor R14, and is connected through capacitor C5 to +450 volts. The screen of tube V5 is operated from a voltage divider, which consists of resistors R12 and R13. The cathode of tube V5 is returned to the +225-volt reference voltage. The grid of tube V4 is connected to the plate of tube V5 whose plate resistor R10 is connected to the plate of tube V4. The output voltage variations from the power supply impressed across C5 are fed to the grid of tube V5. The plate current of tube V5 will therefore vary with its grid. The plate of V5 being connected to the plate of V4 controls the current flow through tube V4, which acts as a variable resistor in series with the output current and maintains the output voltage constant. Capacitor C4 filters irregularities in rectifier V3 output. Resistor R9 is a discharge path for C4.

g. The d-c voltage is used to operate the low-voltage stages of the oscilloscope. It is provided by rectifying ac applied to the plates of V6 and V7. Current can only flow one way in the tubes; therefore, dc appears at their cathodes. This output is pulsating and is filtered by capacitor C7 and the regulator circuit consisting of V9 and V10. The +225-volt (fig. 152) full-wave rectifier-type power supply uses parallel connected rectifier tubes V6 and V7 for greater current capacity. Capacitor C7 filters the output of these rectifier tubes. Resistor R21 is a bleeder resistor for filter capacitor C7. When the equipment is shut off, capacitor C7 will discharge through R21. Tube V10 is the regulating amplifier. Resistor R22 is the plate resistor for tube V10. Resistors R23 and R24 provide a screen voltage divider network, capacitor C8 is the grid a-c bypass capacitor, resistor R25 is the grid current limiting resistor, and resistors R26, R27, and R28 are the +225-volt d-c output voltage divider. Parallel-connected tube V9 is the series regulator tube. Resistor R11 shunts V9, which reduces the tube dissipation while keeping the regulation within acceptable limits.

h. A voltage calibration circuit (fig. 153) is included to measure the voltage deflection of the oscilloscope. This circuit provides a squared 60-cycle a-c voltage, which is displayed on the scope and is calibrated so that its value may be read directly from the panel controls. To measure an unknown voltage, adjust the height of the calibrating voltage to match the height of the unknown signal, then read the value from the panel controls. Both signals are the same height, therefore both are of the same value (par. 55*c*). The a-c voltage is applied to crystal rectifiers CR1, CR2, and CR3 through R30. The output is developed across R31, R4, and applied to voltage divider R33, R34, and R3. It is then fed through switch S2B to vertical input amplifier V12. Resistor R35 is calibrated, so that voltage may be read directly from it when the switch is in the calibrate position.

i. The –140-volt supply (fig. 154) is provided by rectifier tube V8 and is filtered by resistor R18 and capacitor C6. Resistor R19, in parallel with R20, is the series voltage dropping resistor for gas-type voltage regulator tube V11. The output is then taken through resistor R29 and is filtered by capacitors C9A, C9B, and C9C. The current flow through voltage regulator V11 varies inversely with the voltage change across V11. This change is dissipated across resistors R19 and R20, resulting in a constant –140-volt d-c output.

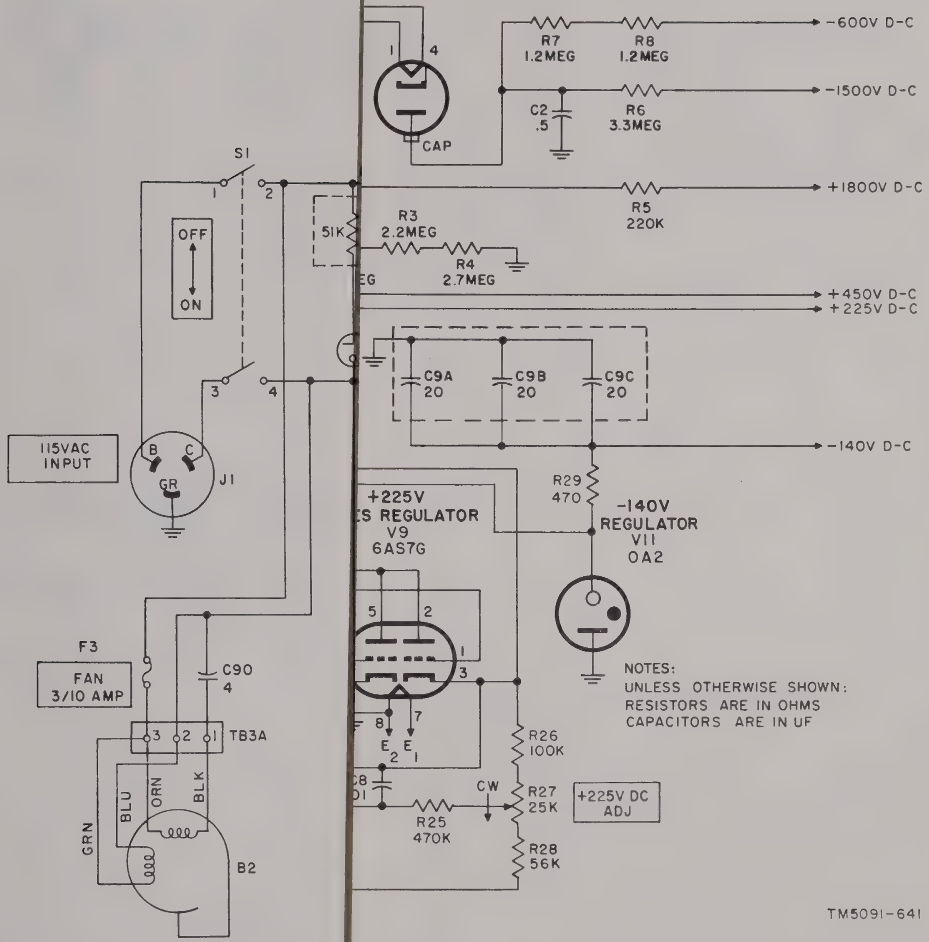

-600V D-C
R7
1.2MEG
R8
1.2MEG
1
4
-1500V D-C
C2
.5
R6
3.3MEG
CAP
S1
1
2
+1800V D-C
R5
220K
OFF
ON
51K
R3
2.2MEG
R4
2.7MEG
EG
+450V D-C
+225V D-C
C9A
20
C9B
20
C9C
20
3
4
115VAC
INPUT
B
C
GR
J1
-140V D-C
R29
470
-140V
REGULATOR
V11
OA2
+225V
S REGULATOR
V9
6AS7G
5
2
1
3
8
7
E2
E1
F3
FAN
3/10 AMP
C90
4
TB3A
3
2
1
GRN
BLU
ORN
BLK
B2
C8
01
R25
470K
CW
R26
100K
R27
25K
R28
56K
+225V DC
ADJ
NOTES:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
TM5091-641

Figure 148. Oscilloscope power supply.

d. The –1,500-volt supply (fig. 149) is rectified by V2 and filtered by resistor R6 and capacitors C2 and C3. The –600 volts is obtained from the same rectifier tube but dropped through R7 and R8.

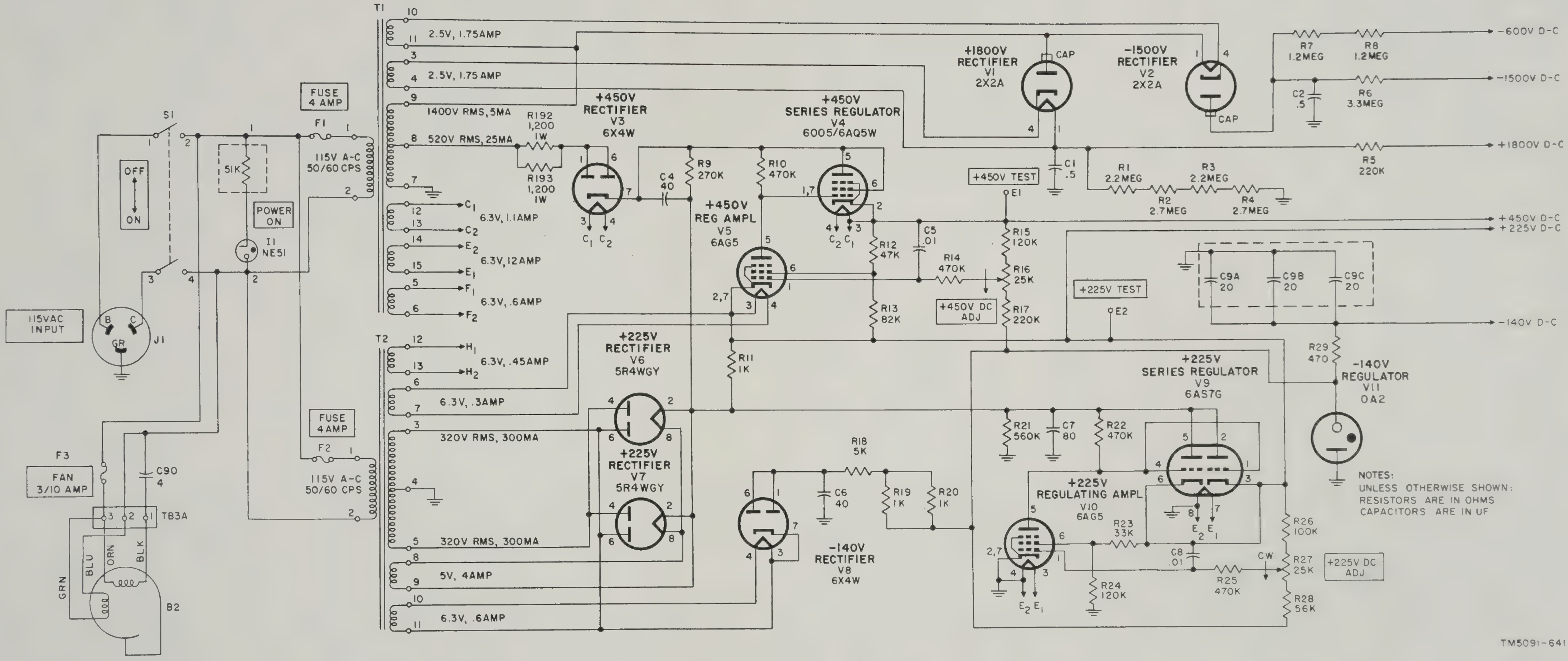
e. The +1,800-volt supply (fig. 150) is rectified by V1 and is filtered by resistor R5 and capacitor C1. Resistors R1 through R4 act as a bleeder circuit and provide a discharge path for capacitor C1.

f. The +450-volt rectifier, V3 (fig. 151), is operated as a diode because both plates are tied together. The tube current is limited by resistors R192 and R193 in parallel. The output is regulated electronically by series regulator V4, the series resistance of which changes to keep the output voltage constant. The +225-volt regulated supply is used as a reference for the +450-volt supply and must be adjusted first. The output of the +450-volt supply is across the voltage divider R15, R16, and R17. The grid of regulator tube V5 is connected to a tap on potentiometer R16 through current limiting resistor R14, and is connected through capacitor C5 to +450 volts. The screen of tube V5 is operated from a voltage divider, which consists of resistors R12 and R13. The cathode of tube V5 is returned to the +225-volt reference voltage. The grid of tube V4 is connected to the plate of tube V5 whose plate resistor R10 is connected to the plate of tube V4. The output voltage variations from the power supply impressed across C5 are fed to the grid of tube V5. The plate current of tube V5 will therefore vary with its grid. The plate of V5 being connected to the plate of V4 controls the current flow through tube V4, which acts as a variable resistor in series with the output current and maintains the output voltage constant. Capacitor C4 filters irregularities in rectifier V3 output. Resistor R9 is a discharge path for C4.

g. The d-c voltage is used to operate the low-voltage stages of the oscilloscope. It is provided by rectifying ac applied to the plates of V6 and V7. Current can only flow one way in the tubes; therefore, dc appears at their cathodes. This output is pulsating and is filtered by capacitor C7 and the regulator circuit consisting of V9 and V10. The +225-volt (fig. 152) full-wave rectifier-type power supply uses parallel connected rectifier tubes V6 and V7 for greater current capacity. Capacitor C7 filters the output of these rectifier tubes. Resistor R21 is a bleeder resistor for filter capacitor C7. When the equipment is shut off, capacitor C7 will discharge through R21. Tube V10 is the regulating amplifier. Resistor R22 is the plate resistor for tube V10. Resistors R23 and R24 provide a screen voltage divider network, capacitor C8 is the grid a-c bypass capacitor, resistor R25 is the grid current limiting resistor, and resistors R26, R27, and R28 are the +225-volt d-c output voltage divider. Parallel-connected tube V9 is the series regulator tube. Resistor R11 shunts V9, which reduces the tube dissipation while keeping the regulation within acceptable limits.

h. A voltage calibration circuit (fig. 153) is included to measure the voltage deflection of the oscilloscope. This circuit provides a squared 60-cycle a-c voltage, which is displayed on the scope and is calibrated so that its value may be read directly from the panel controls. To measure an unknown voltage, adjust the height of the calibrating voltage to match the height of the unknown signal, then read the value from the panel controls. Both signals are the same height, therefore both are of the same value (par. 55*c*). The a-c voltage is applied to crystal rectifiers CR1, CR2, and CR3 through R30. The output is developed across R31, R4, and applied to voltage divider R33, R34, and R3. It is then fed through switch S2B to vertical input amplifier V12. Resistor R35 is calibrated, so that voltage may be read directly from it when the switch is in the calibrate position.

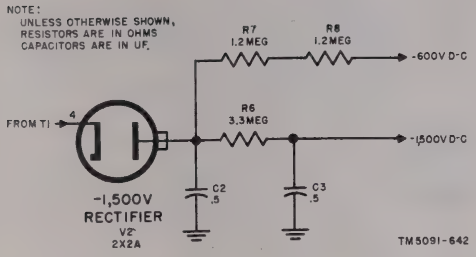
i. The –140-volt supply (fig. 154) is provided by rectifier tube V8 and is filtered by resistor R18 and capacitor C6. Resistor R19, in parallel with R20, is the series voltage dropping resistor for gas-type voltage regulator tube V11. The output is then taken through resistor R29 and is filtered by capacitors C9A, C9B, and C9C. The current flow through voltage regulator V11 varies inversely with the voltage change across V11. This change is dissipated across resistors R19 and R20, resulting in a constant –140-volt d-c output.


T1
10
11
2.5V, 1.75AMP
3
4
2.5V, 1.75 AMP
9
1400V RMS, 5MA
8
520V RMS, 25MA
7
12
13
6.3V, 1.1AMP
C_1
C_2
14
15
6.3V, .12AMP
E_2
E_1
5
6
6.3V, .6AMP
F_1
F_2
FUSE 4 AMP
F1
115V A-C 50/60 CPS
S1
OFF
ON
51K
POWER ON
I1 NE51
115VAC INPUT
B
C
GR
J1
F3
FAN 3/10 AMP
C90 4
TB3A
GRN
BLU
ORN
BLK
B2
R192 1,200 1W
R193 1,200 1W
+450V RECTIFIER V3 6X4W
C4 40
R9 270K
R10 470K
+450V SERIES REGULATOR V4 6005/6AQ5W
+450V REG AMPL V5 6AG5
R11 1K
R12 47K
R13 82K
C5 .01
R14 470K
+450V DC ADJ
+450V TEST
E1
R15 120K
R16 25K
R17 220K
+1800V RECTIFIER V1 2X2A
CAP
-1500V RECTIFIER V2 2X2A
C1 .5
C2 .5
R1 2.2MEG
R2 2.7MEG
R3 2.2MEG
R4 2.7MEG
R5 220K
R6 3.3MEG
R7 1.2MEG
R8 1.2MEG
-600V D-C
-1500V D-C
+1800V D-C
+450V D-C
+225V D-C
-140V D-C
C9A 20
C9B 20
C9C 20
+225V TEST
E2
R29 470
-140V REGULATOR V11 OA2
T2
6.3V, .45AMP
H_1
H_2
6.3V, .3AMP
320V RMS, 300MA
5V, 4AMP
6.3V, .6AMP
FUSE 4 AMP
F2
115V A-C 50/60 CPS
+225V RECTIFIER V6 5R4WGY
+225V RECTIFIER V7 5R4WGY
-140V RECTIFIER V8 6X4W
R18 5K
C6 40
R19 1K
R20 1K
+225V SERIES REGULATOR V9 6AS7G
R21 560K
C7 80
R22 470K
+225V REGULATING AMPL V10 6AG5
R23 33K
C8 .01
R24 120K
R25 470K
CW
R26 100K
R27 25K
R28 56K
+225V DC ADJ

NOTES:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF

TM5091-641

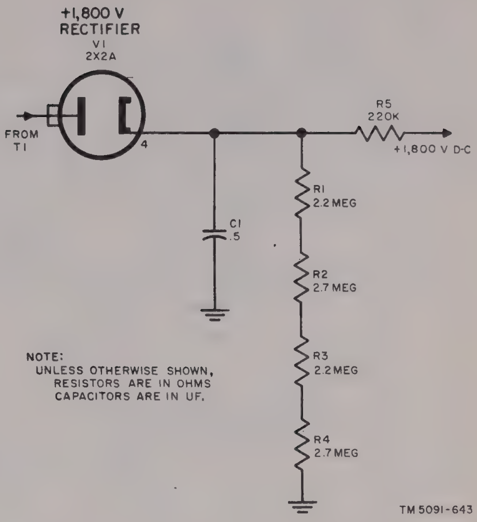
Figure 148. Oscilloscope power supply.


R7
1.2 MEG
R8
1.2 MEG
-600V D-C
FROM T1
4
R6
3.3 MEG
-1,500V D-C
C2
.5
C3
.5
-1,500V
RECTIFIER
V2
2X2A

NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.

TM 5091-642

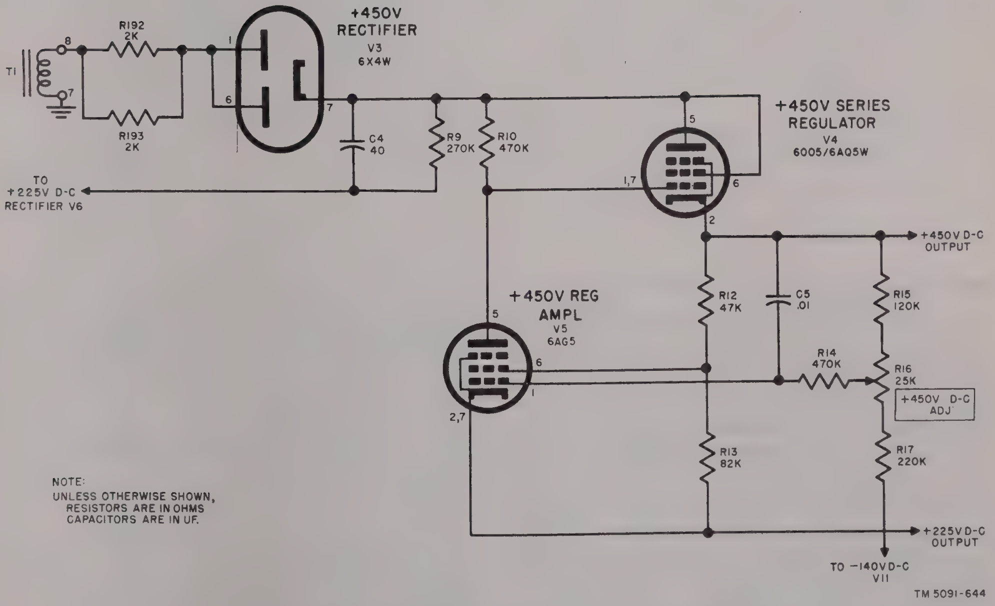
Figure 149. Oscilloscope —1,500- and —600-volt supply.


+1,800 V
RECTIFIER
V1
2X2A
FROM
T1
4
R5
220K
+1,800 V D-C
C1
.5
R1
2.2 MEG
R2
2.7 MEG
R3
2.2 MEG
R4
2.7 MEG

NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.

TM 5091-643

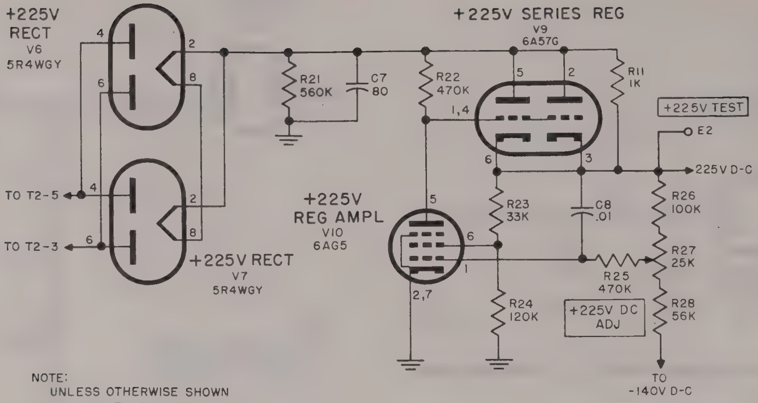
Figure 150. Oscilloscope +1,800-volt supply.


T1
8
7
R192
2K
R193
2K
1
6
7
+450V
RECTIFIER
V3
6X4W
C4
40
R9
270K
R10
470K
TO
+225V D-C
RECTIFIER V6
5
1,7
6
2
+450V SERIES
REGULATOR
V4
6005/6AQ5W
+450V D-C
OUTPUT
R12
47K
C5
.01
R15
120K
+450V REG
AMPL
V5
6AG5
5
6
1
2,7
R14
470K
R16
25K
+450V D-C
ADJ
R13
82K
R17
220K
+225V D-C
OUTPUT
TO -140V D-C
V11

NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.

TM 5091-644

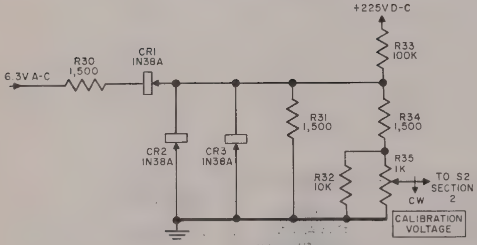
Figure 151. Oscilloscope +450-volt regulated supply.


+225V
RECT
V6
5R4WGY
TO T2-5
TO T2-3
+225V RECT
V7
5R4WGY
R21
560K
C7
80
R22
470K
+225V SERIES REG
V9
6A57G
R11
1K
+225V TEST
E2
225V D-C
+225V
REG AMPL
V10
6AG5
R23
33K
C8
.01
R26
100K
R27
25K
R25
470K
R24
120K
+225V DC
ADJ
R28
56K
TO
-140V D-C

NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.

TM 5091-645

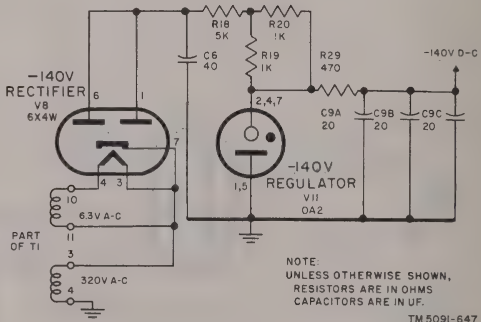
Figure 152. Oscilloscope +225-volt supply.


+225V D-C
6.3V A-C
R30
1,500
CR1
IN38A
R33
100K
R31
1,500
R34
1,500
CR2
IN38A
CR3
IN38A
R32
10K
R35
1K
TO S2
SECTION
2
CW
CALIBRATION
VOLTAGE

NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS.

TM 5091-646

Figure 153. Oscilloscope voltage calibration circuit.


R18
5K
R20
1K
C6
40
R19
1K
R29
470
-140V D-C
-140V
RECTIFIER
V8
6X4W
C9A
20
C9B
20
C9C
20
-140V
REGULATOR
V11
0A2
6.3V A-C
PART
OF T1
320V A-C

NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.

TM 5091-647

Figure 154. Oscilloscope —140-volt supply.

140. Oscillator Vertical Amplifier System

a. General. The vertical deflection system amplifies or attenuates the signal being observed and couples it to the vertical deflection plates of the crt. The maximum gain of the circuit is 100. Use of an oscilloscope probe is necessary so that desired voltages can be observed without loading. The probe is a 9-megohm resistor (R36 and R37) in parallel with capacitor C10, both in series with the normal input circuit of the oscilloscope (fig. 266). When the time constant of this resistance-capacitance circuit is adjusted to be equal to the time constant of the oscilloscope, attenuation of the input signal is achieved without distortion of any of the frequency components of the observed signal. The following stages comprise the vertical deflection system: vertical input amplifier V12, phase splitter cathode follower V13, and push-pull vertical output amplifier tubes V14 and V15. The output of V14 and V15 is coupled to crt vertical deflection plates D3 and D4.

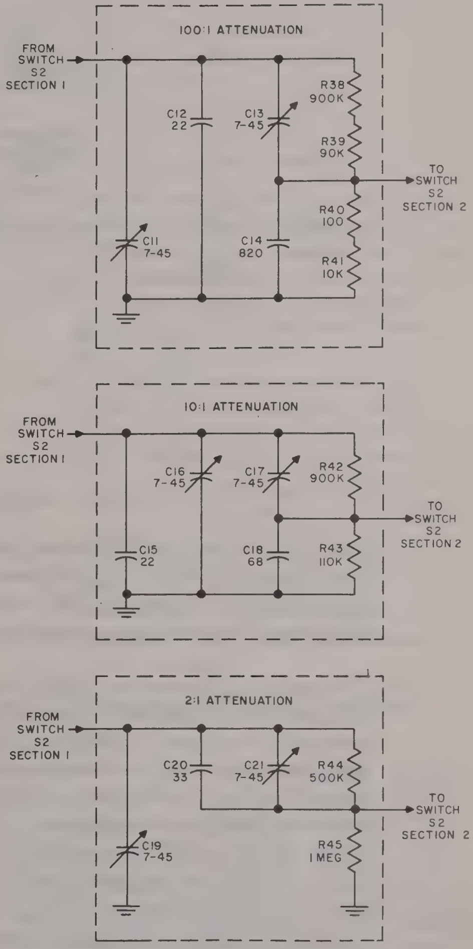
b. Vertical Attenuator (fig. 155). The signals applied to the input of the vertical amplifier are introduced through the vertical attenuator, which is a five-position rotary switch (S2).

Four positions provide attenuations of 100:1, 10:1, 2:1, and 1:1. The fifth position is for calibration purposes. The attenuation is achieved without distortion by shunting the attenuator resistors with capacitors, so that the product of resistance-capacitance is constant. These capacitors can be adjusted to provide minimum distortion (par. 197*g*). The 100:1 attenuator consists of resistors R38, R39, R40, and R41 and capacitors C11, C12, C13, and C14. The 10:1 unit consists of resistors R42 and R43 and capacitors C15, C16, C17, and C18. The 2:1 attenuator consists of resistors R44 and R45 and capacitors C19, C20, and C21.

c. Vertical Input Amplifier (fig. 156).

(1) A video amplifier must be able to amplify uniformly a wide band of frequencies. However, a typical resistance-coupled audio amplifier has a characteristic amplification that falls off both at high and low frequencies. To prevent this, some form of *compensation* is necessary. The reduced gain at the high frequencies is due to the reduction of plate load impedance caused by the shunting effect of interelectrode and distributed capacity. This may be compensated for by adding an inductance in series with the load resistor. This is known as *shunt* compensation. The same effect may be accomplished by a coil in *series* with the coupling capacitor. Both methods are used in the vertical input amplifier circuit.

(2) The input stage, tube V12, uses a method of series-shunt peaking to achieve the maximum gain at high frequencies. Series peaking is accomplished by isolating the input capacitance of tube V13 from the output capacitance of tube V12 by the network that consists of series compensating inductor L2 and resistor R57. Resistors R50 and R51 are decoupling resistors for the plate circuit of V12. Capacitor C24A is the decoupling capacitor, R53 and R52 in parallel are the plate load, L1 is the shunt compensating inductor, R54 is a parasitic suppressor resistor, R56 is the screen grid voltage dropping resistor, and C24B is the screen grid bypass capacitor. Resistor R46 is the grid return, and R47 and R48 form a voltage divider to set the grid bias. Capacitor C23 is the coupling capacitor from S2B, and R49 is a parasitic suppressor resistor. Parallel-connected resis-


100:1 ATTENUATION
FROM SWITCH S2 SECTION 1
C12 22
C13 7-45
R38 900K
R39 90K
TO SWITCH S2 SECTION 2
R40 100
C11 7-45
C14 820
R41 10K
10:1 ATTENUATION
FROM SWITCH S2 SECTION 1
C16 7-45
C17 7-45
R42 900K
TO SWITCH S2 SECTION 2
C15 22
C18 68
R43 110K
2:1 ATTENUATION
FROM SWITCH S2 SECTION 1
C20 33
C21 7-45
R44 500K
TO SWITCH S2 SECTION 2
C19 7-45
R45 1 MEG

NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF.

TM 5091-648

Figure 155. Oscilloscope vertical attenuator.

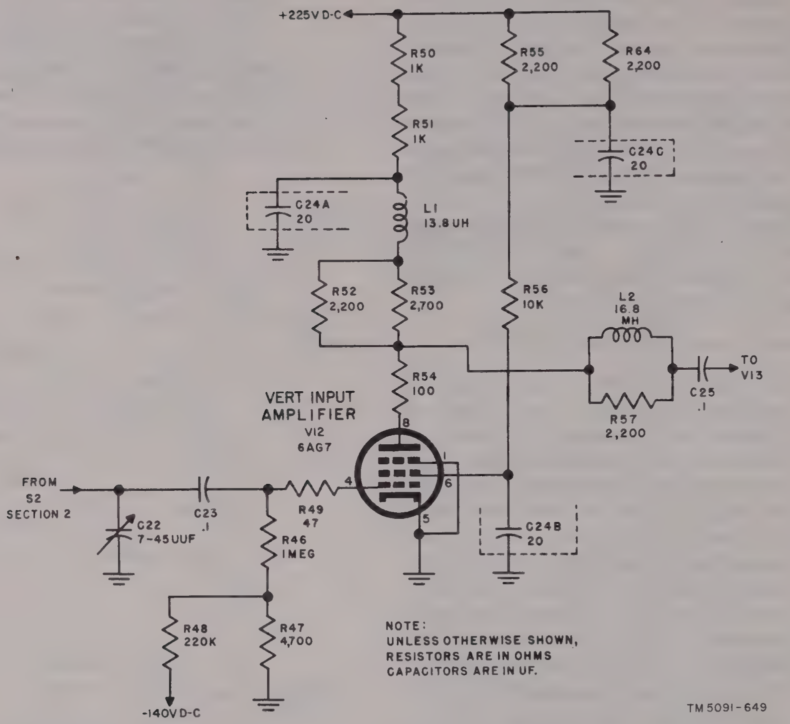

+225V D-C
R50
1K
R51
1K
R55
2,200
R64
2,200
C24C
20
C24A
20
L1
13.8 UH
R52
2,200
R53
2,700
R56
10K
L2
16.8
MH
TO
V13
R54
100
C25
.1
R57
2,200
VERT INPUT
AMPLIFIER
V12
6AG7
8
1
6
4
5
FROM
S2
SECTION 2
C23
.1
C22
7-45UUF
R49
47
R46
1MEG
C24B
20
R48
220K
R47
4,700
-140V D-C
NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
TM 5091-649

Figure 156. Oscilloscope vertical input amplifier.

tors R55 and R64 provide screen grid decoupling and C24C is the decoupling capacitor. Capacitor C22 is the attenuator trimmer bypass capacitor.

(3) The gain of the over-all plate coupling circuit of amplifier tube V12 is maintained constant from very low audio frequencies to video frequencies as high as 5 mc. Potentiometer R59 is used to adjust the low-frequency response as the signal is coupled from V12 to V13. Low-frequency compensation is achieved with the circuit that consists of resistors R58 and R59 and capacitor C26A. This circuit overcomes the reduction in gain at low frequencies that results from the increase in reactance of C25.

d. Cathode Follower V13. Cathode follower stage V13 (fig. 157) isolates the relatively high input capacitance of tube V14 from the plate circuit of tube V12, and drives low resistance potentiometer VERT GAIN control R68. This low value of resistance helps to avoid high-frequency (h-f) attenuation caused by distributed capacitance. The grid of V13 is a high-impedance circuit, but the cathode (from which part of the output is taken) is a low-impedance circuit. To maintain a good low-frequency response, in this cathode follower stage, a large coupling capacitor, C27, is required. This capacitor is mounted to minimize its capacitance to ground, which would otherwise decrease the h-f response of the circuit. Resistor R61 is the grid return resistor, R60 and R62 are the voltage divider network to set the fixed grid bias. Resistors R66 and R67 are the cathode resistors. Resistor R65 is a low value plate load resistor to permit a small out-of-phase signal to be taken off the plate to feed the internal synchronizing circuit. Capacitor C27 is the output coupling capacitor, and resistors R68 and R69 (VERT GAIN) are the cathode-follower load. Voltage developed across R69 and R68 (VERT GAIN) is fed to vertical output tube V14 through coupling capacitor C28.

e. Push-pull Vertical Amplifier (fig. 158).

(1) The output stage of the vertical amplifier consists of tubes V14 and V15. Push-pull operation of this stage is achieved without the use of a transformer but by using common cathode resistors R79 and R80. For a complete description of a cathode-coupled push-pull amplifier, refer to paragraph 141*i*(2). The portion of the output from tube V14 is cathode-coupled to the grid of V15.

(2) By proper selection of cathode resistors the signals applied to the grids will be equal. Each stage includes a low-frequency compensation network to correct for the coupling effect of the vertical deflection plates of the cathode-ray tube. The input load circuit to tube V14 contains variable resistor R71, which adjusts for variations in the tolerances of R58 and R61. Inductor L3 isolates the input capacitance of tube V14, thus providing h-f peaking. As in the output of tube V12, series-shunt peaking is used in tubes V14 and V15 to provide h-f compensation. Resistors R76 and R86 are plate parasitic suppressor resistors; R74 and R75 in parallel and R84 and R85 in parallel are the tube plate loads; L4 and L5 are the series-shunt peaking coils; and resistors R72 and R73 in parallel and R82 and R83 in parallel are the plate decoupling resistors. Capacitors C26B and C26C are the plate decoupling capacitors. Resistor R78 is the screen grid voltage decoupling resistor for both tubes, and C30 is the bypass capacitor. Resistors R77 and R81 connect the suppressor grid to the cathode return circuit and capacitors C29 and C31 are the suppressor grid bypass capacitors. Resistors R89 and R90 are a voltage divider network and provide the bias for both tubes. Resistors R87, R88, and R90, connected in series, are the grid return for V15. Resistors R70, R71, and R90, connected in series, are the grid return for V14. Resistor R87 provides a load for the timing pips and R88 and C32 provide a filter to isolate the signal applied to V14 from the grid of V15. The timing-pip circuit is described in paragraph 142. Capacitor C32 bypasses the timing markers (pips), isolating them from the voltage divider network.

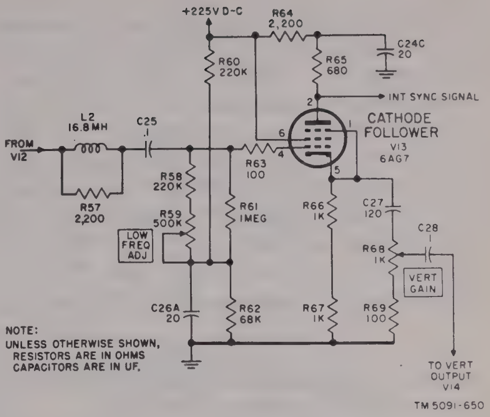


Figure 157. Oscilloscope cathode-follower stage V13.

141. Oscilloscope Horizontal Amplifier System

a. General. The sweep circuits provide means for horizontally deflecting the beam of the crt, for synchronizing the horizontal with the vertical pattern, and for positioning the pattern so that any desired portion of it may be observed. An unblanking circuit is provided so that the beam is brightened during sweeps. (The spot that appears at the left-hand portion of the sweep during triggered operation can be reduced in intensity by turning the INTENSITY control counterclockwise.)

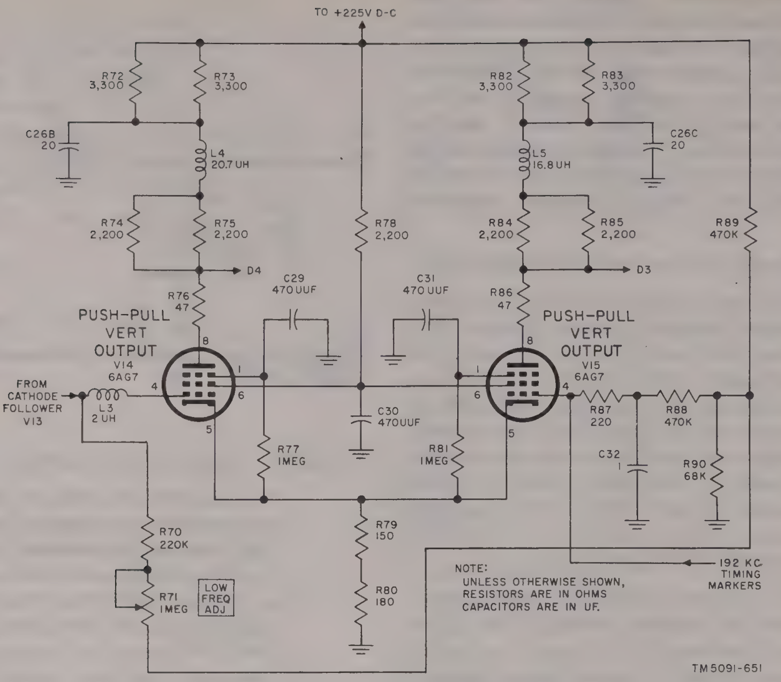

TO +225V D-C
R72 3,300
R73 3,300
R82 3,300
R83 3,300
C26B 20
C26C 20
L4 20.7 UH
L5 16.8 UH
R74 2,200
R75 2,200
R78 2,200
R84 2,200
R85 2,200
R89 470K
D4
D3
C29 470 UUF
C31 470 UUF
R76 47
R86 47
PUSH-PULL VERT OUTPUT V14 6AG7
PUSH-PULL VERT OUTPUT V15 6AG7
8
1
4
6
5
FROM CATHODE FOLLOWER V13
L3 2 UH
C30 470UUF
R77 IMEG
R81 IMEG
R87 220
R88 470K
C32 1
R90 68K
R79 150
R70 220K
R71 IMEG
LOW FREQ ADJ
R80 180
192 KC TIMING MARKERS
NOTE: UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS CAPACITORS ARE IN UF.
TM5091-651

Figure 158. Oscilloscope vertical amplifier output stage.

b. Sweep-phase Circuit (fig. 159). A synchronizing signal from the common unit multiplexer or demultiplexer sections is fed through J4 (MTPX SYNC INPUT) or J5 (DEMTPX SYNC INPUT) to the grid of 8-kc amplifier tube V16A. This signal can be used to trigger the sweep circuits when the SYNC SELECTOR switch is in the DEMULTIPLEXER SYNC or MULTIPLEXER SYNC position. The output taken from the tuned plate tank circuit (C33 and L6) of tube V16A is applied to the rotor of two-phase autosyn B1. This autosyn functions as a transformer that has a rotary primary coil with two stationary secondary coils. One stationary coil acts as the transformer secondary with the other stationary coil mounted at a right angle to this secondary coil. The rotor, as the primary of the transformer, induces voltages into the fixed stators of the autosyn. These voltages vary in amplitude, but not in phase, as the rotor is turned. Because the stator coils are mounted at right angles to each other when the voltage in one is a maximum, the voltage in the other is a minimum. The sum of these voltages is applied across a phase-shift combination consisting of resistor R92 and capacitor C37. The phase of the voltage that appears on pin 7 of tube V16B, therefore, is a function of the angle through which the rotor of B1 is turned. Thus, turning over the autosyn rotor 360° will rotate the phase of the signal that appears at pin 7 of tube V16B over 360° with respect to the 8-kc sync signal applied to jack J4 or J5. Inductor L6 and capacitor C33 form a resonant circuit at 8 kc and are the plate load of tube V16A; resistor R91 is the cathode-biasing resistor. Capacitor C34 is the cathode bypass capacitor; C35 provides the output coupling; and C36 is the bypass capacitor across the load. Tube V16B amplifies the sweep phase as adjusted by SWEEP PHASE B1. Resistor R95 is the plate load, and R94, with capacitor C38A, provides power supply decoupling. Capacitor C39 is the output coupling capacitor.

c. Trigger Phase Splitter (fig. 160). The trigger phase splitter controls the polarity of the signal applied to the grid of sync amplifier V18 of the sweep-trigger circuit so that proper triggering is accomplished, regardless of the signal applied to the grid of tube V17. When SYNC SELECTOR switch S3B is in the DEMTPX position, the trigger signal to the grid of tube V18 is applied from the cathode of tube V17. Thus, there is no phase inversion. When the switch is in the MTPX position, the grid signal to tube V18 is taken from the plate of tube V17, and thereby inverted. Resistor R96 is the grid return for tube V17. Capacitor C41 is the coupling capacitor to the arm of SYNC SELECTOR switch S3. Resistor R99 and capacitor C40B are a decoupling network. Resistors R97 and R98 form a screen grid voltage divider, and C40A is the screen grid bypass capacitor. Resistor R100 is the plate load, and R101 is the cathode load.

d. Sync Amplifier (fig. 160). Sync amplifier tube V18 is used to amplify the signal from tube V17, the trigger phase splitter. By adjusting the negative bias applied to its grid with TRIGGER potentiometer R102, the amplitude of the signal, which controls the triggering of the sweep multivibrator, can be adjusted. Resistors R103 and R102 are the bias voltage divider circuit. Resistor R104 is the grid return, R105 is the plate load, and R106 is the cathode resistor.

e. Trigger-coupling Diode (fig. 161). Triggering of the sweep multivibrator is accomplished through the plate circuit of multivibrator V20 by the trigger-coupling diode, tube V19A. The diode is connected so that only the negative signals applied to its cathode are passed through to the plate of multivibrator tube V20. When the trigger pulse has once triggered the multivibrator, it is disconnected from the remaining multivibrator tube V21, and multivibrator V20 will not trigger again until it returns to its quiescent state.

f. Multivibrator (fig. 161).

(1) The multivibrator consists of tubes V20 and V21 and provides the sweep gate signal and an unblanking pulse to the crt.

(2) When quiescent, tube V21 is conducting and V20 is cut off. The plate of V21 is connected through resistor R113, and capacitor C42 is connected to the control grid of V20. The plate of V20 is connected through switch S4A, which connects either one of timing capacitors C43, C44, C45, or C46 into the circuit to the control grid of V21. The cathodes of the two tubes V20 and V21 are grounded. The grid of V20 is returned to ground through potentiometer R110 (STAB control). This control provides up

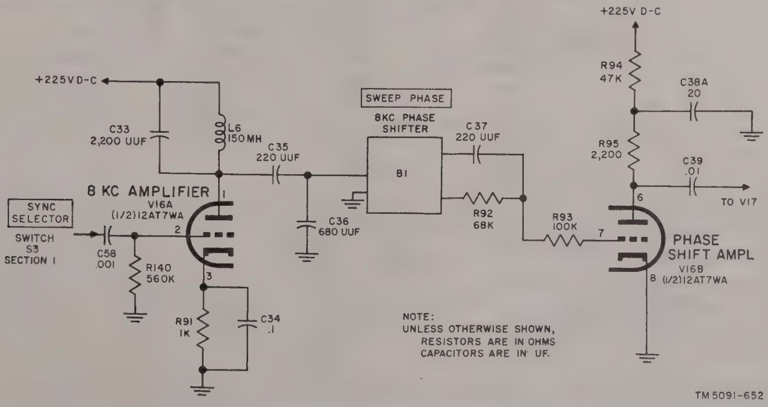

+225V D-C
+225VD-C
R94
47K
C38A
20
SWEEP PHASE
8KC PHASE
SHIFTER
C33
2,200 UUF
L6
150MH
C35
220 UUF
C37
220 UUF
R95
2,200
C39
.01
B1
8 KC AMPLIFIER
V16A
(1/2)12AT7WA
1
SYNC
SELECTOR
SWITCH
S3
SECTION I
2
C58
.001
R140
560K
3
C36
680 UUF
R92
68K
R93
100K
6
TO V17
7
PHASE
SHIFT AMPL
V16B
(1/2)12AT7WA
8
R91
1K
C34
.1
NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
TM 5091-652

Figure 159. Oscilloscope horizontal sweep phase circuit.

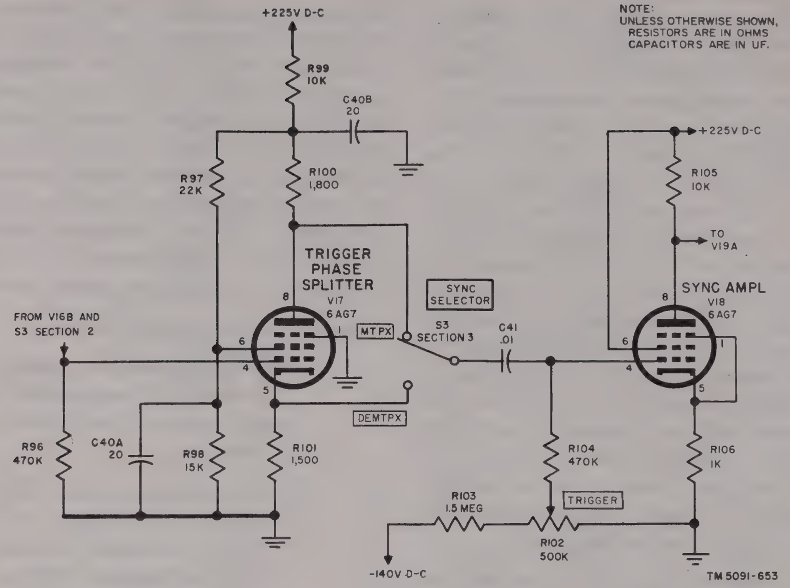

NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
+225V D-C
R99
10K
C40B
20
R97
22K
R100
1,800
TRIGGER
PHASE
SPLITTER
V17
6AG7
SYNC
SELECTOR
MTPX
S3
SECTION 3
C41
.01
DEMTPX
FROM V16B AND
S3 SECTION 2
R96
470K
C40A
20
R98
15K
R101
1,500
R104
470K
R103
1.5 MEG
TRIGGER
R102
500K
-140V D-C
+225V D-C
R105
10K
TO
V19A
SYNC AMPL
V18
6AG7
R106
1K
8
6
4
5
1
TM 5091-653

Figure 160. Oscilloscope trigger phase splitter V17 and sync amplifier V18.

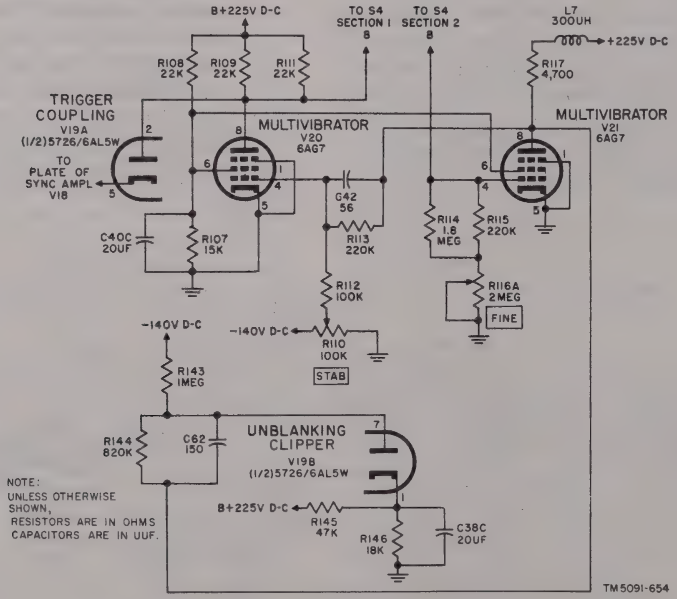

B+225V D-C
TO S4
SECTION 1
8
TO S4
SECTION 2
8
L7
300UH
+225V D-C
R108
22K
R109
22K
R111
22K
R117
4,700
TRIGGER
COUPLING
V19A
(1/2)5726/6AL5W
TO
PLATE OF
SYNC AMPL
V18
MULTIVIBRATOR
V20
6AG7
MULTIVIBRATOR
V21
6AG7
C42
56
R113
220K
R114
1.8
MEG
R115
220K
C40C
20UF
R107
15K
R112
100K
R116A
2MEG
FINE
-140V D-C
-140V D-C
R110
100K
STAB
R143
1MEG
R144
820K
C62
150
UNBLANKING
CLIPPER
V19B
(1/2)5726/6AL5W
B+225V D-C
R145
47K
R146
18K
C38C
20UF
NOTE:
UNLESS OTHERWISE
SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF.
TM 5091-654

Figure 161. Oscilloscope multivibrator.

to –140-volt negative bias and permits either triggered or recurrent operation.

(3) In the quiescent state, tube V21 is conducting and tube V20 is cut off. When a negative pulse passes through trigger-coupling tube V19A, it decreases the voltage on the plate of tube V20 and on the grid of tube V21. This more negative grid voltage cuts off V21, whose plate goes more positive. The plate of V21 is coupled to the grid of V20. The positive-going plate of tube V21 causes the control grid of V20 to become more positive and tube V20 will start to conduct.

(4) When V20 starts to conduct, its plate voltage drops. This voltage is coupled to the grid of V21, which causes the plate current to decrease and plate voltage to increase. The triggering action is complete when V21 is cut off and V20 is conducting heavily.

(5) Timing capacitor C43, C44, C45, or C46 (fig. 162 and 266) will hold the grid of V21 at cutoff potential for a time, determined by its capacitance and the resistance R114, R115, and R116A. Once the capacitor discharges, tube V21 will again conduct and the tubes return to their original, or quiescent, condition.

(6) Resistors R108 and R107 form the screen grid voltage divider, and C40C is the screen grid bypass capacitor. Resistor R112 is the grid return resistor for V20; R111 and R109 provide the plate load for V20; and R117 and L7 act as the plate load of V21.

g. Unblanking Circuit. The trace of the crt is normally cut off and visible during sweeps; the positive rectangular wave that appears at the plate of tube V21 is applied to the crt control grid through buffer cathode follower V27B (fig. 66). This wave is clipped by diode unblanking clipper V19B to insure a uniform intensity of the trace as the beam sweeps across the face of the tube. The buffer cathode-follower tube V27B acts as an impedance transformer preventing the wiring and grid capacitance of the crt from loading the plate circuit of the multivibrator. This is because the cathode follower has a high input (grid) impedance and a low output (cathode) impedance. Resistor R146 and capacitor C38C are the diode load; R143 and R144 act as a voltage divider to –140 volts to set the V27B grid bias, and resistors R145 and R146 act as a voltage divider to set the voltage on the cathode of V19B. Resistor R142 is the cathode resistor for V27B.

h. Sweep Generator (fig. 162).

(1) The crt requires a voltage varying linearly with time to move its spot from one side of the scope screen to the other (sweep). This is accomplished by charging a capacitor to a given voltage at a linear rate and then discharging it rapidly. The rate of charge, and, therefore, the sweep speed, is a function of the capacitor, and the resistance through which the charging and discharging current must flow. Predetermined ranges are provided by switching in various combinations of capacitors.

(2) The sweep generator consists of sawtooth sweep generator tube V22 and sweep control tube V23. These tubes provide voltage for deflecting the crt spot across the screen at a chosen rate. Multivibrator tube V20 applies a negative pulse to the grid of normally heavily conducting sawtooth sweep generator tube V22. The negative pulse cuts off this stage and permits the plate voltage to rise exponentially toward the +450 B+ supply to which it is connected. The exponential rate of rise is determined by HOR GAIN resistor R116B in series with parallel-connected resistors R121 and R122, tube V23, and either one of capacitors C50, C51, C52, or C48 in parallel with C49. The capacitor is in series with the resistance network. To maintain as linear a charge rate as possible, the capacitor is permitted to charge to only 25 volts

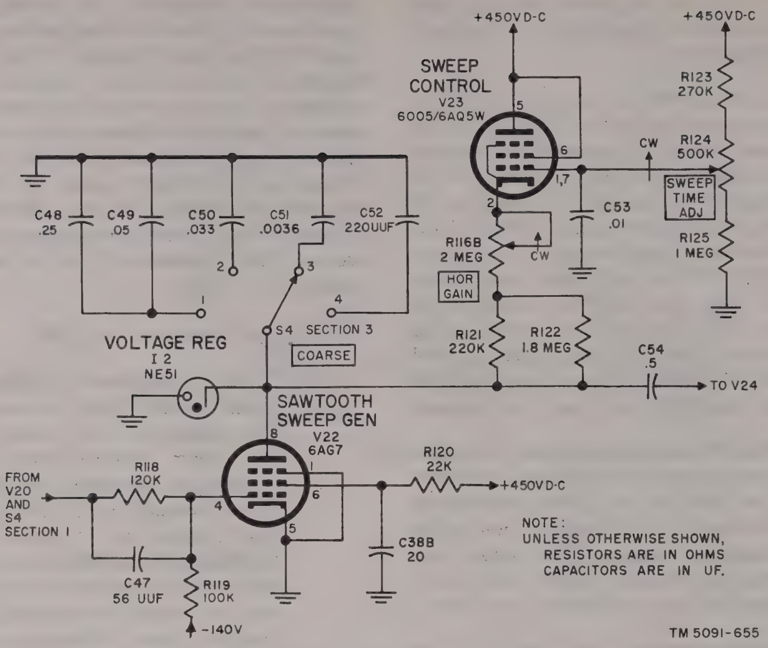

+450VD-C
+450VD-C
SWEEP CONTROL
V23
6005/6AQ5W
5
6
1,7
2
CW
R123
270K
R124
500K
SWEEP TIME ADJ
R125
1 MEG
C48
.25
C49
.05
C50
.033
C51
.0036
C52
220UUF
C53
.01
R116B
2 MEG
CW
HOR GAIN
1
2
3
4
S4
SECTION 3
COARSE
R121
220K
R122
1.8 MEG
C54
.5
TO V24
VOLTAGE REG
I 2
NE51
SAWTOOTH SWEEP GEN
V22
6AG7
8
1
6
4
5
R120
22K
+450VD-C
FROM V20 AND S4 SECTION 1
R118
120K
C38B
20
C47
56 UUF
R119
100K
-140V
NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
TM 5091-655

Figure 162. Oscilloscope sweep generator.

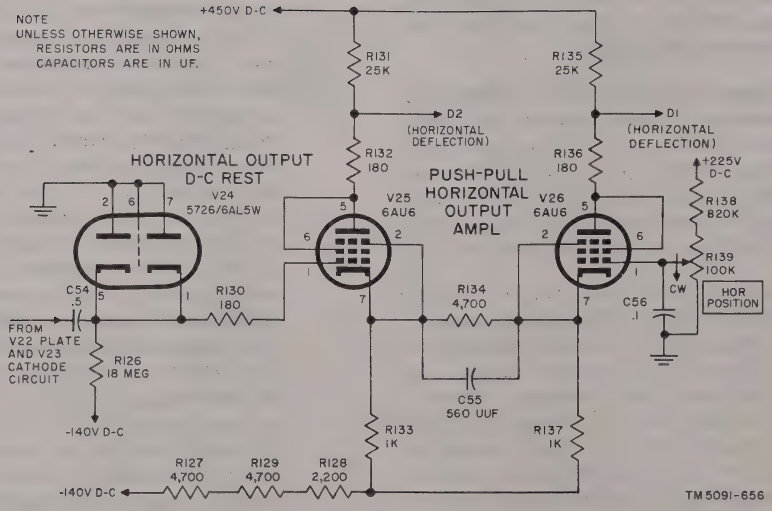

NOTE
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
+450V D-C
R131
25K
R135
25K
D2
(HORIZONTAL DEFLECTION)
D1
(HORIZONTAL DEFLECTION)
R132
180
R136
180
+225V D-C
HORIZONTAL OUTPUT D-C REST
V24
5726/6AL5W
2
6
7
5
1
PUSH-PULL HORIZONTAL OUTPUT AMPL
V25
6AU6
V26
6AU6
5
6
2
1
7
R138
820K
R139
100K
CW
HOR POSITION
C54
.5
R130
180
R134
4,700
C56
.1
FROM V22 PLATE AND V23 CATHODE CIRCUIT
R126
18 MEG
-140V D-C
C55
560 UUF
R133
1K
R137
1K
R127
4,700
R129
4,700
R128
2,200
-140V D-C
TM 5091-656

Figure 163. Oscilloscope sweep amplifier.

(about 6 per cent of the driving voltage) by shunting it with neon bulb I 2, which conducts at that voltage. When the voltage across the capacitor rises to 25 volts, I 2 conducts, placing a low resistance across the capacitor. The maximum voltage that can be developed across the capacitor is therefore 25 volts. By that time the negative pulse applied to the grid has disappeared, and tube V22 returns to its normally heavily conducting state. This discharges the capacitor and permits the cycle to repeat. Sweep control tube V23 is used to control the rate at which the capacitor selected by COARSE switch S4 will charge, hence controlling the frequency of the horizontal sweep.

(3) Resistor R119 is the grid biasing resistor for V30, R120 is the screen grid voltage dropping resistor, and C38B is the screen grid bypass capacitor. Resistor R118 maintains the grid positive by returning to B+, and capacitor C47 is the grid coupling capacitor.

(4) Sweep control tube V23 is a cathode follower. With the control grid of V23 held at a-c ground by capacitor C53, its cathode provides a low-impedance source of voltage. The adjustable grid bias provided by resistors R123, R125, and potentiometer R124 (SWEEP TIME ADJUST) permits adjusting the sweep time without disturbing the required resistance ratio in the cathode circuit. It does this by varying the conduction of the tube, thus effectively changing its resistance.

i. Sweep Amplifier (fig. 163).

(1) Because the sawtooth sweep generator provides only 25 volts of sweep voltage at the plate of tube V22, amplification is required to obtain the 350 volts necessary to deflect the beam across the face of the crt. This amplification is obtained with tubes V25 and V26, which comprise a cathode-coupled push-pull driver stage for the horizontal deflection plate of the crt.

(2) A positive signal applied to the grid of V25 appears positive on its cathode. Tubes V25 and V26 have a common cathode circuit. Thus, a positive voltage on the cathode of V26 causes a positive-going signal to appear on the plate of V26, which is out of phase with the negative signal on the plate of V25. The cathode coupling generates equal but opposite signals on the plates of V25 and V26.

(3) The HOR POSITION control R139, in the grid circuit of tube V26, controls the d-c potential applied to the grid and, therefore, the current which the tube draws. By controlling the current flow through the tubes, the d-c voltages on the plates of V25 and V26 are also controlled, which fixes the horizontal position of the trace.

(4) The sweep voltage is coupled through capacitor C54. Some charge may remain on this capacitor after a single sweep. This charge, when added to the next sweep voltage, would cause a slight horizontal displacement of the trace. To prevent trace displacement with change in sweep speed, horizontal output d-c restorer diode V24 is connected from the grid side of the capacitor with the plate connected to ground to insure that the horizontal trace always starts from zero potential. It does this by conducting whenever a positive voltage appears on its plate. Accordingly, the capacitor is discharged whenever a positive voltage appears on its plate. Resistor R126 is the grid return for tube V25, and also provides the cathode potential for d-c restorer V24. Resistor R130 is a grid limiting resistor, R131 is the plate load, and R133 is part of the cathode load. For tube V26, resistor R135 is the plate load, and R137 is part of the cathode load.

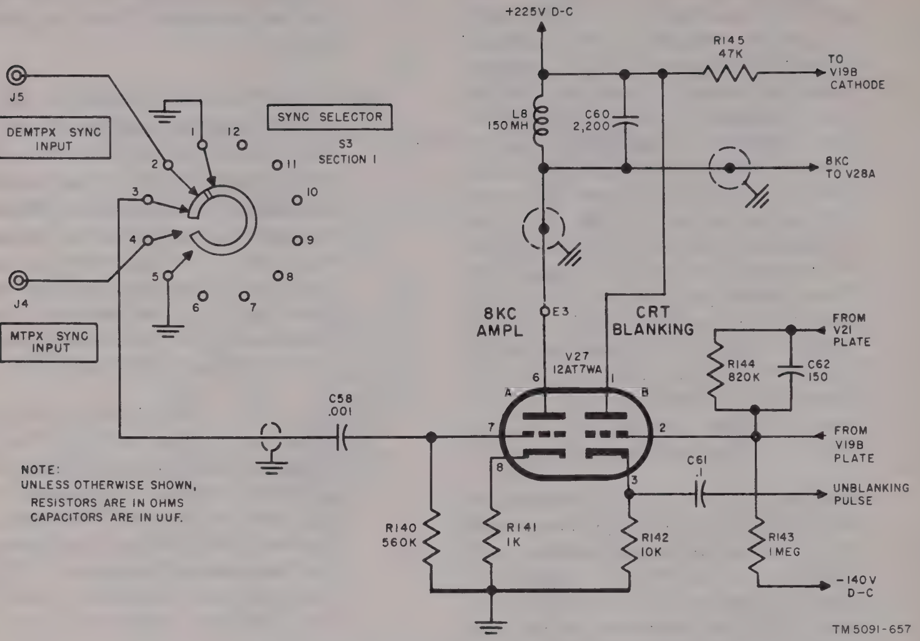

+225V D-C
R145
47K
TO
V19B
CATHODE
J5
DEMTPX SYNC
INPUT
SYNC SELECTOR
S3
SECTION 1
1
2
3
4
5
6
7
8
9
10
11
12
J4
MTPX SYNC
INPUT
L8
150 MH
C60
2,200
8KC
TO V28A
E3
8KC
AMPL
CRT
BLANKING
V27
12AT7WA
A
B
FROM
V21
PLATE
R144
820K
C62
150
C58
.001
FROM
V19B
PLATE
C61
.1
UNBLANKING
PULSE
R140
560K
R141
1K
R142
10K
R143
1MEG
-140V
D-C
NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF.
TM 5091-657

Figure 164. 8-kc amplifier crt blanking cathode follower V27A.

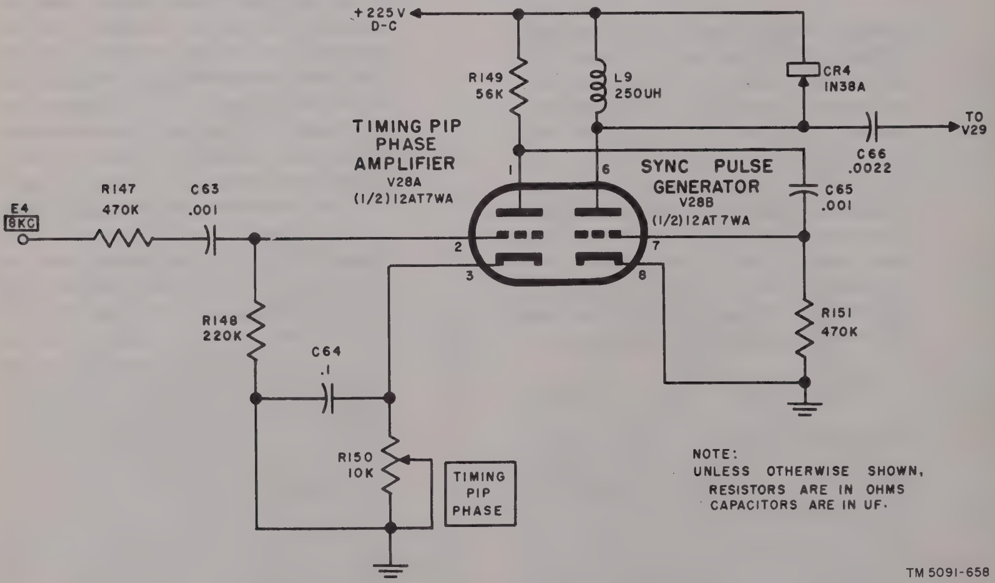

+225V
D-C
R149
56K
L9
250UH
CR4
1N38A
TO
V29
TIMING PIP
PHASE
AMPLIFIER
V28A
(1/2)12AT7WA
C66
.0022
SYNC PULSE
GENERATOR
V28B
(1/2)12AT7WA
C65
.001
E4
8KC
R147
470K
C63
.001
R148
220K
C64
.1
R151
470K
R150
10K
TIMING
PIP
PHASE
NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
TM 5091-658

Figure 165. Oscilloscope timing-pip-phase amplifier and sync pulse generator V28A.

Resistors R132 and R136 are parasitic suppressor resistors, and R127, R128, and R129 are voltage dropping resistors in the cathode circuit of both tubes. Capacitor C55 is the cathode-coupling capacitor, and resistor R134 is its discharge path. The output voltage of V25 is coupled to crt horizontal deflection plate D2, and the output of V26 is coupled to crt horizontal deflection plate D1. The sweep, or movement of the beam across the screen, is thereby controlled by the output of V25 and V26.

142. Timing-pip Generator
(fig. 164, 165, and 166)

To align the channel pulses of the multiplexer group, a timing-pip generator (sometimes referred to as the timing-marker generator) circuit provides pulses separated by 5.2 usec. These timing pips can be used for calibrating the time base of the screen when viewing other wave forms. The repetition rate of a wave form with a period of 5.2 usec is 192 kc; therefore, one of the important functions of the timing-marker generator is to obtain an accurate 192-kc signal from an 8-kc sync signal. This 8-kc oscillator sync signal is obtained from the multiplexer and applied to the grid of 8-kc amplifier V27A through SYNC SELECTOR switch S3A.

a. 8-kc Sync Amplifier V27A (fig. 164). The 8-kc amplifier tube, V27A, provides a single stage of 8-kc amplification. The signal is obtained from MTPX SYNC INPUT jack J4 or DEMTPX SYNC INPUT jack J5 through switch S3A. Capacitor C58 is the coupling capacitor from switch S3A, R140 is the grid return resistor, R141 is the cathode resistor, and inductor L8 with capacitor C60 acts as the 8-kc plate load. The output of V27A is coupled to the grid of timing-pip-phase amplifier V28A through isolation resistor R147 and coupling capacitor C63.

b. 8-kc Timing-pip-phase Amplifier V28A (fig. 165). Tube V28A may be operated at various bias points on its characteristic curve by varying potentiometer R150 to determine at what point tube V28A will conduct and to position its plate signal in time. Resistor R148 is the grid return resistor, R149 is the plate load, and capacitor C64 is the cathode bypass capacitor. The square wave output of V28A is developed by the large grid signal driving the tube to saturation.

c. Sync Pulse Generator V28B. The square wave output of V28A is fed through coupling capacitor C65 to the grid of sync pulse generator V28B. This tube has a shock-excited inductor L9 in its plate circuit. The inductor is shock-excited by the negative cycle of the input signal. Damping diode CR4 is connected so that L9 is damped when the plate end attempts to go positive, and thus dissipates all the energy stored in inductor L9 after the first negative switching. This generates an 8-kc negative pulse, which is coupled by capacitor C66 to discriminator tube V29. Resistor R151 is the grid return resistor.

d. Discriminator V29 (fig. 166). A discriminator is a circuit, the output of which varies with some characteristic of the input, usually frequency. Discriminator V29 compares the output of V30B (192-kc oscillator) with an external signal of the same frequency (the 8-kc pulses). The 8-kc reference is applied to the cathodes of V29 through R154 and R155. One output of the 192-kc oscillator is fed through capacitor C67 and resistor R152 to the cathode of V29A. The other output of the 192-kc oscillator is fed through C73, amplified by V31A, and then fed through C81 and R155 to the cathode of V29B. The total discriminator output appears across resistors R156, R157, and R158 as a d-c voltage, filtered by capacitor C68. The d-c level of this signal is biased to the proper value by a power supply voltage taken across divider network resistors R160 and R161 and isolated by R159. This level may be adjusted by PIP LOCKING control R161 to set the point of operation and, therefore, the frequency of V30B. The voltage from the discriminator will then add or subtract from this level to vary the frequency. However, values are chosen so that when the 192-kc oscillator goes up, the voltage from the discriminator resulting from that rise brings it back down, and vice versa.

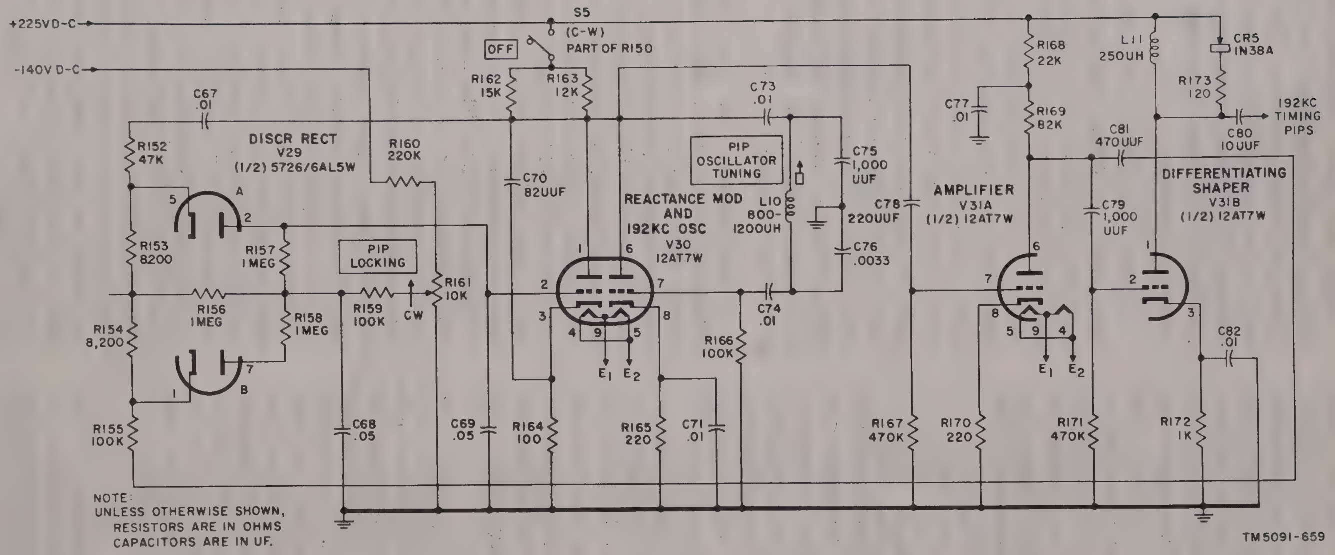

+225VD-C
-140V D-C
S5
(C-W)
PART OF R150
OFF
R162 15K
R163 12K
C67 .01
R152 47K
DISCR RECT
V29
(1/2) 5726/6AL5W
A
5
2
R153 8200
R157 1MEG
R156 1MEG
R158 1MEG
R154 8,200
B
1
7
R155 100K
R160 220K
PIP LOCKING
R159 100K
CW
R161 10K
C68 .05
C69 .05
C70 82UUF
REACTANCE MOD AND 192KC OSC
V30
12AT7W
1
6
2
7
3
8
4
9
5
E1
E2
R164 100
R165 220
C71 .01
C73 .01
PIP OSCILLATOR TUNING
L10 800-1200UH
C75 1,000 UUF
C78 220UUF
C76 .0033
C74 .01
R166 100K
R167 470K
AMPLIFIER
V31A
(1/2) 12AT7W
6
7
8
5
9
4
E1
E2
R170 220
R168 22K
C77 .01
R169 82K
C81 470UUF
C79 1,000 UUF
R171 470K
L11 250UH
CR5 1N38A
R173 120
C80 10UUF
192KC TIMING PIPS
DIFFERENTIATING SHAPER
V31B
(1/2) 12AT7W
1
2
3
C82 .01
R172 1K
NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
TM5091-659

Figure 166. Oscilloscope timing-marker generator.

e. Reactance Modulator V30A. The reactance modulator controls the frequency of V30B by functioning as a reactor in parallel with the plate circuit. The V30A reactance modulator plate is connected directly to the plate of oscillator V30B. Capacitor C70, connected between plate and cathode of this reactance modulator stage, has a current flowing through it that leads the voltage across it by 90°. This current flows through resistor R164 and produces a voltage drop across it that is in phase with this current. The voltage across resistor R164 is the 192-kc signal applied to this stage and is almost 90° displaced in phase with the instantaneous plate voltage. This causes a current to flow in the tube which is almost 90° out of phase with the voltage across it and the magnitude of which is proportional to the transconductance of the tube. This condition is similar to the action of an inductance shunted across the tank circuit of the oscillator. The transconductance, and therefore the magnitude of the inductance, is controlled by the grid voltage obtained from the discriminator. This control results in an automatic method for stabilizing the frequency of the 192-kc oscillator. Resistors R162 and R163 in parallel supply the +225 volts to tube V30. TIMING PIP PHASE switch S5 disables V30B when turned fully counterclockwise.

f. 192-kc Oscillator V30B. Tube V30B comprises a modified Colpitts oscillator that generates the 192-kc sine wave. When the tank circuit, consisting of inductance L10 and capacitors C75 and C76, goes into oscillation, voltages 180° out of phase with each other exist at opposite ends of L10. The voltage that appears at the grid of V30B is amplified and inverted in phase at the plate, thus sustaining oscillations in the tank circuit. Capacitors C73 and C74 couple the tank circuit to V30B. Resistor R165 is the cathode return resistor, C71 is the cathode bypass capacitor, R166 is the grid return resistor, and C78 is the signal output coupling capacitor.

g. 192-kc Amplifier V31A and Differentiating Shaper V31B. The train of sine waves that appears at the plate of V30B is coupled by capacitor C78 to the grid of 192-kc amplifier V31A where it is further amplified and applied to the grid of differentiating shaper V31B. This wave is of sufficiently large amplitude to cause a large current to flow as the positive swing is applied to the grid. The oscillation normally caused in the plate circuit by the inductive plate load L11 is damped after the first negative swing by the damping diode (CR5 in series with resistor R173). A sharp negative pulse is generated by this stage on each positive half-cycle applied to the grid of V31B. This is the timing pip. For V31A, resistor R168 and capacitor C77 form the plate decoupling network; R169 is the plate load, R167 is the grid return, and R170 is the cathode resistor. Capacitor C79 is the output coupling capacitor, and resistor R171 is the grid return for V31B. Resistor R172 is the cathode resistor, and C82 is its bypass capacitor. The output is fed through capacitor C80 to the grid of push-pull vertical amplifier V15 (par. 140*e*).

143. Audio Test Set TS–762/TC

a. General (fig. 167). Audio Test Set TS–762/TC is a transmission-measuring set used to test the audio operation of the multiplexer group. The major sections of the test set are: a calibrated 1,000-cycle low distortion oscillator, frequency variable over a range of 970 to 1,030 cycles with output level of –35 to +10 dbm in calibrated steps of 1 db, and a high gain amplifier that provides one response with F1A line weighting and another response with 1,000-cycle elimination. The receiving section can measure +10 to –70 dbm and the receive attenuator is calibrated in steps of 10 db. In addition, there is a specially dampened db meter that measures from +3 to –20 db, a regulated power supply, and provisions for rapidly checking and recalibrating the level of the oscillator and amplifier.

b. Block Diagram Analysis (fig. 167).

(1) Tubes V1 and V2 comprise the 1,000-cycle Wein bridge oscillator, V3 is a phase inverter, and V4 is a push-pull amplifier. These tubes are in the oscillator or transmitting section. In the receiver section, V5 is a limiter of the input and V6 and V7 are amplifiers. Tube V8 is the power supply rectifier, and V9 the associated voltage regulator. The F1A filter provides a means of distortion measurement.

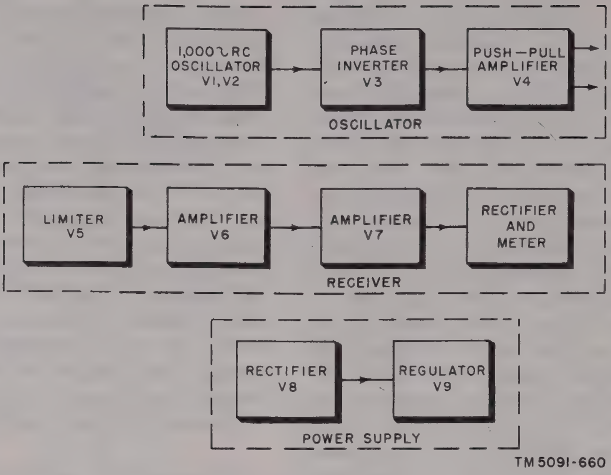

1,000∿RC OSCILLATOR V1, V2
PHASE INVERTER V3
PUSH—PULL AMPLIFIER V4
OSCILLATOR
LIMITER V5
AMPLIFIER V6
AMPLIFIER V7
RECTIFIER AND METER
RECEIVER
RECTIFIER V8
REGULATOR V9
POWER SUPPLY
TM 5091-660

Figure 167. Audio Test Set TS–762/TC, block diagram.

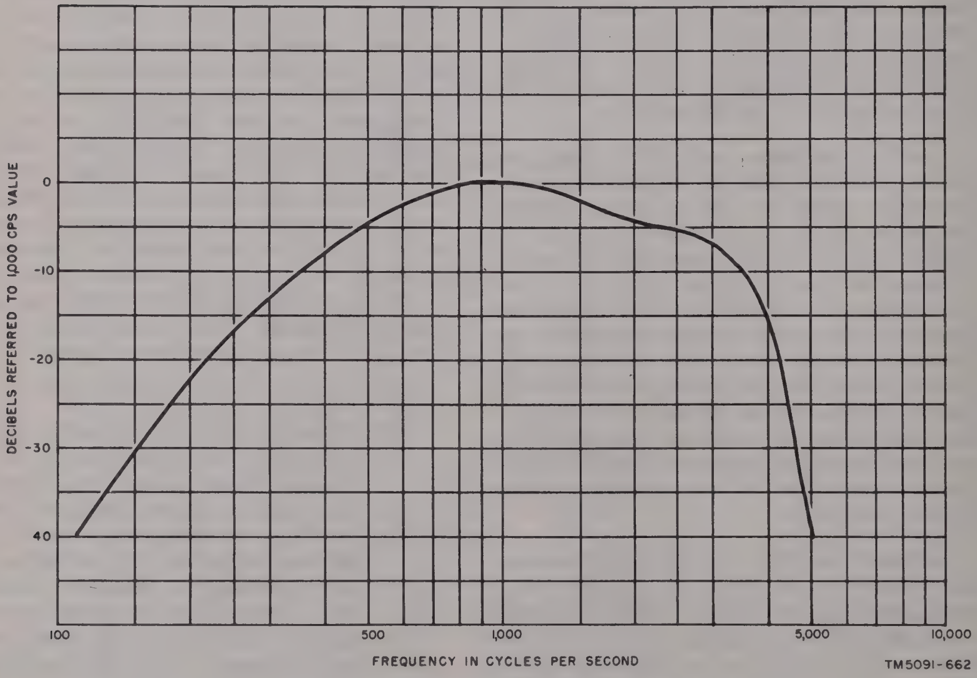


Figure 168. F1A curve.

(2) F1A represents a type of frequency response typical of telephone circuits that is determined by the response of telephone components, such as headsets. A typical curve is shown in figure 168. Only the frequencies shown in this curve can be received; therefore, it would not be significant to measure noise except in relation to this curve because noise outside of the response cannot be received. In measuring distortion, use a frequency of 1,000 cycles because the F1A curve has no effect at this frequency.

c. Oscillator.

(1) *Oscillator V1 and amplifier V2* (fig. 169). The oscillator is a resistance-capacitance (Wein bridge) type. The voltage is fed back from the output to the input in the proper phase to sustain oscillations. The amplitude of the feedback is controlled by lamp I 1, the resistance of which varies with the current. The oscillator consists of tube V1 and associated components, isolation amplifier tube V2, and thermistor I 1. The fixed-frequency-determining elements are capacitors C1 and C2, resistors R1, R3, R5, and R7, and potentiometers R2 and R4. The 970- to 1,030-cycle adjustment is obtained from dual potentiometer R4, where maximum resistance corresponds to 970 cycles, and minimum resistance corresponds to 1,030 cycles. BRIDGE BALANCE potentiometer R2 is a frequency vernier adjustment. The amount of signal fed back to the cathode of tube V1 is set by resistor R8 and potentiometer R6 (DISTORTION) through capacitor C5. Resistor R11 is the plate load of tube V1, and R9 and R10 are the screen grid voltage divider. Capacitor C3A is the screen bypass capacitor and C4 is the coupling capacitor to tube V2. Resistor R12 is the grid return for tube V2, R13 is the cathode resistor, and R14 and R15 are the screen grid voltage divider; C3B is the screen grid bypass capacitor. The output is taken from the divider, which consists of resistors R17 and R19 and potentiometer R18 (ADJ SEND). Resistor R16 is the plate resistor for V2.

(2) *Inverter V3 and push-pull amplifier V4* (fig. 170).

(*a*) The 1,000-cycle signal from the oscillator is fed to tube V3, which consists of two sections in parallel. Inverter tube V3 splits the phase of the input signal and provides the two signals equal in voltage but opposite in phase for the following push-pull amplifier V4. Voltage developed across the ADJ SEND potentiometer is applied through capacitor C6 to the grid of V3A. The ADJ SEND potentiometer controls the voltage applied to the next stage. The parallel tubes allow greater current and lower output impedance. The output signal developed across plate load resistor R21 is fed to the grid of V4A through coupling capacitor C7. The voltage developed across cathode load resistor R23 is fed to the grid of V4B through coupling capacitor C8. Both resistance values are equal, therefore equal but out-of-phase voltages are applied to the grids of the push-pull amplifiers. Resistor R22 is the cathode-biasing resistor; it is purposely left unbypassed to introduce degeneration to cut down distortion.

(*b*) Tube V4A and V4B is a push-pull output amplifier. The signal from phase splitter V3 is fed through capacitors C7 and C8 to its grids. Resistors R24 and R25 are the grid return resistors, and R26 and R28 are the cathode resistors in series with sections of potentiometer R27 (OUTPUT BALANCE control). This potentiometer has its center tap grounded and each end in series with the cathode resistor of one of the two tubes. Varying it varies

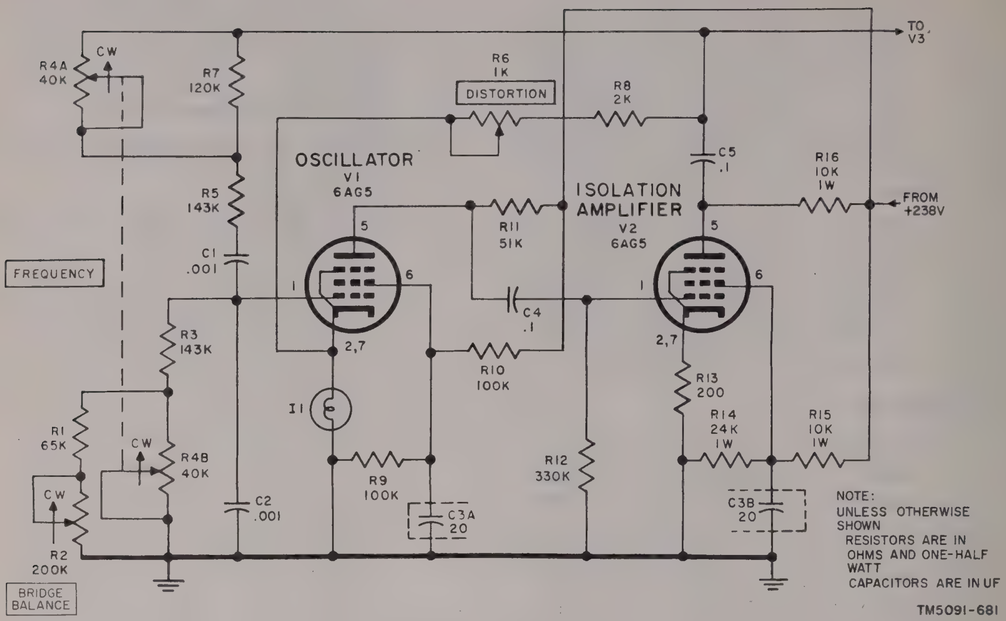

TO V3
R4A 40K
CW
R7 120K
R6 1K
DISTORTION
R8 2K
OSCILLATOR
V1
6AG5
C5 .1
ISOLATION AMPLIFIER
V2
6AG5
R16 10K 1W
FROM +238V
R5 143K
R11 51K
5
5
C1 .001
FREQUENCY
1
6
1
6
C4 .1
2,7
2,7
R3 143K
R10 100K
R13 200
I1
R1 65K
CW
R4B 40K
R9 100K
R12 330K
R14 24K 1W
R15 10K 1W
CW
C2 .001
C3A 20
C3B 20
R2 200K
BRIDGE BALANCE
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS AND ONE-HALF WATT
CAPACITORS ARE IN UF
TM5091-681

Figure 169. Oscillator V1 and amplifier V2.

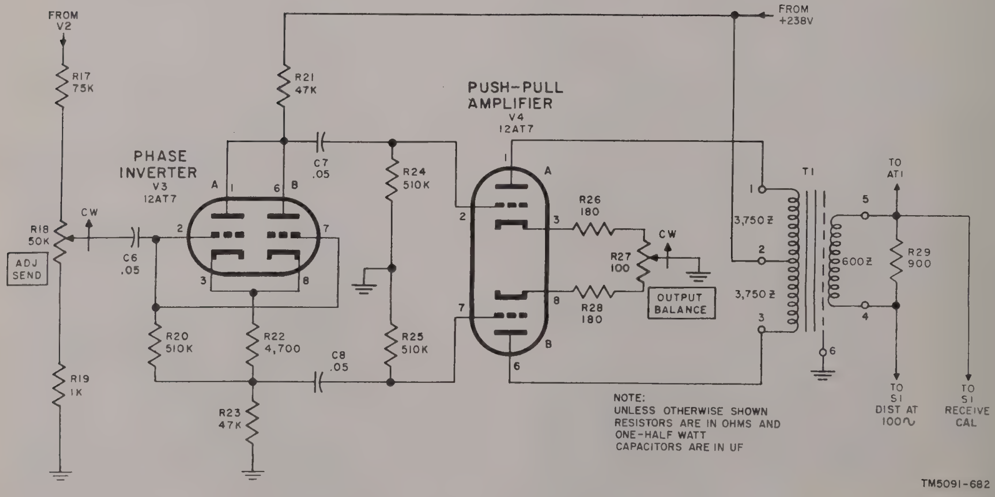

FROM V2
FROM +238V
R17 75K
R21 47K
PUSH-PULL AMPLIFIER
V4
12AT7
PHASE INVERTER
V3
12AT7
A
1
6
B
C7 .05
R24 510K
1
A
T1
TO AT1
R18 50K
CW
ADJ SEND
C6 .05
2
7
3
8
2
3
R26 180
CW
R27 100
OUTPUT BALANCE
1
3,750 Ƶ
2
3,750 Ƶ
3
5
600 Ƶ
4
6
R29 900
7
8
R28 180
B
6
R20 510K
R22 4,700
C8 .05
R25 510K
R19 1K
R23 47K
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS AND ONE-HALF WATT
CAPACITORS ARE IN UF
TO S1 DIST AT 100∿
TO S1 RECEIVE CAL
TM5091-682

Figure 170. Inverter V3 and push-pull amplifier V4.

both cathode resistors and therefore controls the amplification of each tube. Turning the control clockwise results in a greater bias on the grid of tube V4B, thereby decreasing the amplification of this half of the push-pull amplifier. Meanwhile, the bias of V4B has decreased and its amplification increases. By varying the bias of each stage in this manner, the gain of each can be made exactly the same. When the OUTPUT BALANCE control is properly adjusted, the gain characteristics of V4A and V4B are identical. The output is fed through transformer T1 to switch S1 to SEND OUT jacks J1 and J2. Capacitors C9 and C10 are coupling capacitors to the output. Resistor R29 is used to make the output impedance 600 ohms. When the SEND CALIBRATE button is pressed, part of the voltage is fed to meter M1. By adjusting the meter to the red line by potentiometer R40, the output may be read directly in dbm when the F1A button is pressed and a load of 600 ohms is placed across SEND OUT jacks J2 and J3. Attenuator AT1 is used for adjusting the output.

d. Receive Section (fig. 171 and 172).

(1) The receive section is a high gain audio amplifier and associated control. RECEIVE IN jacks J4 and J5 feed into 600-ohm balanced-input transformer T2. Capacitor C13 is a d-c blocking capacitor that couples the two halves of the primary. Resistor R43, connected across the secondary of T2, stabilizes the T2 impedance. The secondary of this transformer is loaded with 10,000-ohm calibrated step-type ladder attenuator AT2, section 1. The output of T2 is fed into four-gang, push-button switch S1, marked SEND, REC, F1A, and DIST at 1,000 cps. The weighting and band-eliminating filters associated with the F1A and DIST buttons offer some attenuation, and their input impedance varies with frequency. To calibrate the gain control correctly, regardless of frequency, T isolation networks R30, R31, R32 and R33, R34, R35 are inserted into the input circuit of each filter. These networks have 10,000-ohm impedance, with a 6-db loss. Distortion filter Z2 has a loss of 1,000 cycles of 70 db or greater. The response curve of F1A filter Z1 is shown in figure 168.

(2) The output of switch S1 is fed into the grid of V6A. Tube V6A and V6B provides two stages of amplification. The RECEIVE DBM calibrated gain control AT2 is divided into two shielded sections operated from a common shaft. This prevents overloading the grid of tube V6A at +10-dbm input and reduces the circuit noises fed to the meter circuit at –30, –40, –50, and –60 dbm. Resistor R44 is the grid return, R46 and R45 are the plate load resistors, R47 is the plate decoupling resistor, R48 is the cathode resistor, and capacitor C14A is the plate decoupling capacitor. Capacitor C15 is the coupling capacitor between the output of V6A and the input of V6B. Resistor R49 is the cathode resistor for V6B. Resistor R50 is a parasitic suppressor, R52 is the plate resistor, R51 is the plate decoupling resistor, and C14B is the plate decoupling capacitor. Tube V7A and V7B provides the final two stages of amplification. The signal from V6B is coupled to the grid through coupling capacitor C16. ADJ REC potentiometer R53 and resistor R54 are grid return resistors. By varying the ADJ REC control, the input signal to V7B is also varied, thereby controlling the signal amplification in the receive section. Resistor R154 is added to the grid circuit so that regardless of the setting of the ADJ REC control, the grid can never be grounded. The output of V17A is taken from across plate load resistor R55, and coupled to V17A through

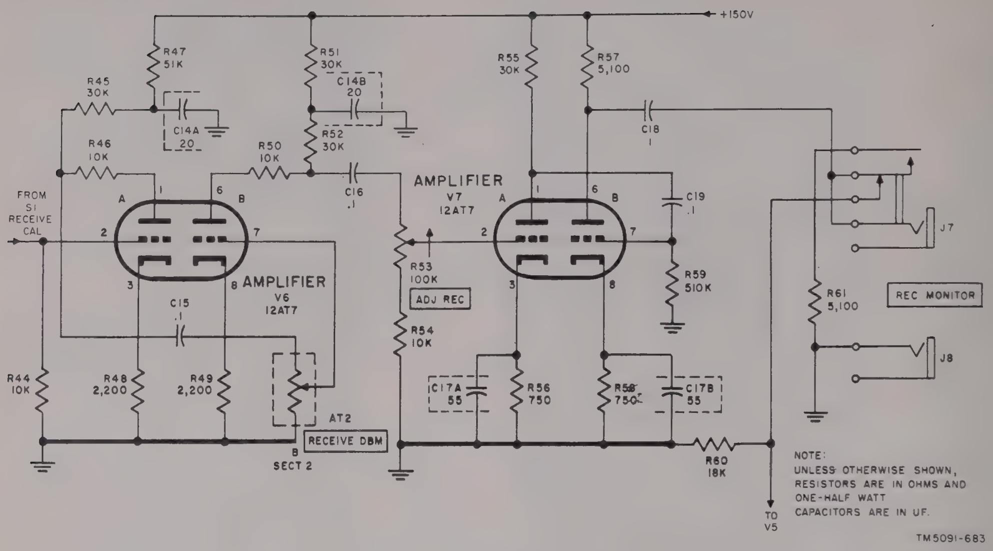

+150V
R47
51K
R45
30K
C14A
20
R46
10K
R51
30K
C14B
20
R52
30K
R50
10K
C16
.1
R55
30K
R57
5,100
C18
1
AMPLIFIER
V7
12AT7
C19
.1
J7
FROM
S1
RECEIVE
CAL
A
B
1
6
2
7
3
8
AMPLIFIER
V6
12AT7
R53
100K
ADJ REC
R59
510K
R61
5,100
REC MONITOR
C15
.1
R54
10K
J8
R44
10K
R48
2,200
R49
2,200
AT2
RECEIVE DBM
B
SECT 2
C17A
55
R56
750
R58
750
C17B
55
R60
18K
TO
V5
NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS AND
ONE-HALF WATT
CAPACITORS ARE IN UF.
TM5091-683

Figure 171. Amplifiers V6 and V7.

capacitor C19. Bias for V7A is supplied by R56 and C17A. The input signal to V7B is developed across grid resistor R59. Resistor R58 and capacitor C17B supply bias for the stage. The signal developed across plate load resistor R57 is fed through coupling capacitor C18 to J7. C18 is the output coupling. The output is taken from jacks J7 and J8. If no plug is inserted in J7, the output is also fed through J7 to limiter V5. Jacks J7 and J8 monitor the received signal. If a plug is inserted in J7, the output of V7B is disconnected from the limiter and applied to J7 and J8. Use jack J8 to monitor the received signal.

(3) Diode-connected limiter V5A and V5B (fig. 172) restricts the output of the receive section. Normally, the +14-volt bias applied to the plates from B+ keeps both tube halves conducting. If the input signal exceeds the bias value in the positive direction, V5B is cut off; if the signal exceeds the bias value in the negative direction, then V5A is cut off. In either case, the output to the meter is limited, which prevents damage. The output from the limiter is then taken through C12, from the cathode (load) resistor R42, to switch S1, and then to the meter bridge, which consists of CR1, CR2, CR3, and CR4. Capacitor C11 is connected across the meter and filters the d-c output of the bridge. The bridge rectifies the ac into dc to operate the meter. The meter sensitivity may be set by resistors R36, R37, R38, and R39, of which REC MTR ADJ R38 is variable.

e. Power Supply. Test set power transformer T3 supplies 235 volts ac to the plates of rectifier tube V8, 5 volts ac for the rectifier filament, and 6.3 volts ac for the heaters of the test set tubes. The filter is a double pi-section, which consists of inductors L1 and L2 and capacitors C20A, C20B, and C21A. This is followed by an additional filter section, which consists of R62, C21B, then by R63, and a voltage regulator tube, V9. Resistor R63 is the voltage dropping and compensating resistor for the voltage regulator tube. Resistors R65 and R64 in series act as a bleeder and

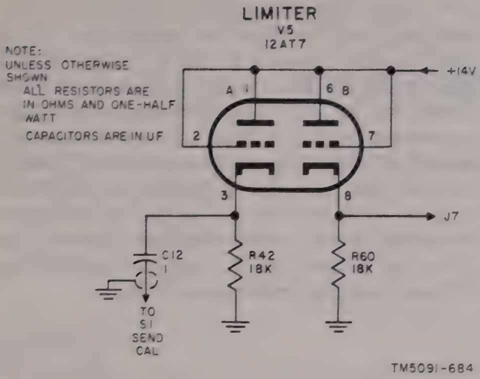


Figure 172. Limiter V5.

voltage divider. The filter is of the capacitor input-type that provides peak voltage output, and the required 155-volt starting voltage for VR9. The three d-c output voltages are +238 volts for the plate circuits of V1, V2, V3, and V4, +150 volts for the plate circuits of V6 and V7, and +14 volts for the plate voltage of V5. Jack J9 is the a-c input jack, S2 the power switch, F1 the fuse, and I 2 is the pilot light.

144. Control Monitor C–1151/TC
(fig. 268)

a. The control monitor provides a switching system for the order-wire handset and a switching arrangement for test signals coming from the modems and mounting rack to the TEL, SEND, or REC section of the audio test set. It provides 20-cps ringing power, an energizing voltage for the microphone of the handset, and contains the signaling bell for order-wire channel 1. In addition, ballast lamp RT1 in series with the 20-cps ringing generator provides short-circuit protection to prevent a direct short circuit from appearing across the output of the 20-cps ringing generator. Any short circuits across the output would burn out RT1, protecting the ringer from short-circuit damage. Resistors R4 and R5 shunt RT1 to provide correct 20-cycle output regulation.

b. The test pair is paralleled to all the modems, and by setting the modem test switch properly can be connected in various ways (par. 129*b*(3)(*c*)). The push-button selector switch test pair controls the connections of the test pair at the control monitor. The positions and their functions are as follows:

(1) REC, the test pair is connected to the test set receive section.

(2) SEND, the test pair is connected to the test set send section.

(3) TEL SET, the test pair is connected to the order-wire circuit.

(4) NORMAL, the test pair is terminated with 620 ohms.

c. A second section of the switch leaves the order-wire telephone connected to channel 1 in all positions except TEL SET, when it is connected to the test pair (subpar. *a* above).

d. Channel 1 should be reserved for order-wire use and normally should not be used for traffic. The bell is attached to channel 1; therefore, it is always possible to use it to ring. The bell is not available when the handset is connected to the test pair.

e. RING switch S2 on the test panel is a momentary contact toggle switch that applies a 20-cps ringing tone to the test pair in the TEL SET position or to the order-wire channel when the NORMAL button is depressed. Depressing RING switch S2 disconnects the 20-cycle ringing signal from the handset.

f. The handset is connected to the test switch by a telephone antisidetone circuit, consisting of L1, C4, C5, and C6. When the push-to-talk switch is depressed, the 6-volt d-c output of the rectifier is applied to the microphone. Voice signals modulate the dc. The modulated dc is applied to windings 2 and 3 of coil L1. Through autotransformer action, a large voltage is built up across L1 and is fed to the line. The pulsating d-c signal is also impressed across windings 3 and 4 of coil L1 and fed through capacitors C4 and C5 in parallel to the earphone. Capacitors C4 and C5 cancel some of the inductive effect of the 3-4 winding, cutting down some of the audio fed to the earphone. They also keep dc out of the earphone. When the distant station rings this station, a large ringing signal would be present across coil L1. Capacitor C6 is purposely made large so that its reactance will limit the ringing current through the handset. When a signal is received, L1 acts as a step-down transformer supplying a greater amount of current to drive the earphone.

g. A power supply is provided to transform and rectify the 115-volt line voltage to 6 volts dc for energizing the microphone of the handset. Rectification of the 6.3 volts ac from the secondary of transformer T1 is accomplished by bridge rectifier CR1, and filtering by capacitive input filter C2 and C3 in combination with resistor R6. The input to transformer T1 is protected by .1-ampere fuse F1. The 115-volt a-c supply for the ringing generator is taken from plug P1. The 1,000-cycle signal is applied through pins A and B of jack J1. Contacts A and B of jack J2 are the order wire, C and D are the test pair, and E and F are the 20-cps ringing contacts. Jack J3 is the a-c input and J4 is the signal output. Resistor R1 is a terminating resistor for the test pair and R2 and R3 are isolating resistors.

CHAPTER 7
FIELD MAINTENANCE

Note. This chapter contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibility is limited only by the tools and test equipment available and by the skill of the repairman.

Section I. GENERAL TROUBLE-SHOOTING TECHNIQUES

145. General

a. Trouble shooting at a field maintenance level includes all the techniques outlined for organizational maintenance (ch 4) and other techniques that may be required to isolate a defective part. The field maintenance instructions are not complete, but supplement the instructions described in chapter 4. The systematic trouble-shooting procedure that begins with the operational and sectionalization checks that can be performed at an organizational level (par. 90 through 99) must be completed by means of sectionalizing, localizing, and isolating techniques described in sections II through VIII of this chapter. Sections II through VIII describe localizing and isolating techniques that must be performed at a field maintenance level.

b. This section contains general information for personnel engaged in trouble shooting. Subsequent sections give specific trouble-shooting information for the functional circuits of Multiplexer Group AN/TCA–1. Trouble should be located and corrected as quickly as possible to minimize time lost because of breakdowns.

146. Trouble-shooting Procedures

a. The first step in servicing a defective set is to sectionalize the fault. *Sectionalization* means tracing the fault to the component responsible for abnormal operation. The second step is to localize the fault. *Localization* means tracing the fault to the defective part responsible for the abnormal condition. The procedure for sectionalizing the trouble is given in chapter 4. The procedure for trouble shooting is given in paragraphs 163 through 197.

b. Some faults (such as burned-out resistors) can be located by sight, smell, and hearing. The majority of faults, however, must be located by checking voltages, resistances, and wave forms.

147. Trouble-shooting Data

Take advantage of the material supplied in this manual to help in locating faults rapidly. Consult the following trouble-shooting data when necessary.

a. Block Diagrams of Systems. The block diagrams present the mechanical and electrical interrelationships of the stages in the systems.

b. Complete Schematic Diagrams. The schematic diagrams include all components separately, and show connections between components.

c. Voltage and Resistance Diagrams. The voltage and resistance diagrams show the normal voltage and resistance values at the pins of all tube sockets. These values were taken with all tubes in their respective sockets.

d. Illustration of Components. Front, top, and bottom views aid in locating and identifying parts.

e. Pin Connections. Pin connections on sockets, plugs, and receptacles are numbered or lettered on the various diagrams.

(1) Viewed from the bottom, pin connections are numbered clockwise around the sockets. On octal sockets, the first pin clockwise from the keyway is pin 1. On seven- or nine-pin miniature sockets, the first pin clockwise from the space is pin 1. Pin numbers appear on both the schematic diagrams and the wiring diagrams so that any tube element can be located readily.

(2) Plugs and receptacles are numbered on the side to which the associated connector is attached. To avoid confusion, individual pins are identified by letters that appear directly on the connector.

148. Special Tool Not Supplied, Shorting Stick

a. General. Use the shorting stick (fig. 173) to discharge capacitors before performing preventive maintenance or trouble shooting. Normally, when the power is turned off, capacitors in the equipment will discharge to ground through bleeder resistors or voltage dividers. If the discharge network should fail, the capacitors are likely to remain charged after the power is turned off. Contact with a charged capacitor might result in severe burns. Shorting capacitors with a shorting stick prevents such accidents.

b. Fabrication. If a shorting stick is not available, make one as follows:

(1) Get a hardwood dowel approximately ½ inch in diameter and 15 inches long.

(2) Drill a ⅛-inch hole in one end of the dowel to a depth of 2 inches.

(3) Press-fit a 3-inch piece of copper or brass bus wire into the hole as far as it will go.

(4) Solder one end of a 36-inch piece of #10 flexible stranded wire to the bus wire as close to the dowel as possible.

(5) Attach a battery clamp to the other end of the wire.

(6) Apply several layers of friction tape over the soldered connection at the bus wire, leaving approximately ½ inch of the bus wire bare.

(7) Continue the tape down over the dowel for a distance of 2 inches.

(8) Form an insulated handle for the shorting stick by winding two layers of rubber tape and two layers of friction tape around the other end of the dowel for a distance of 6 inches.

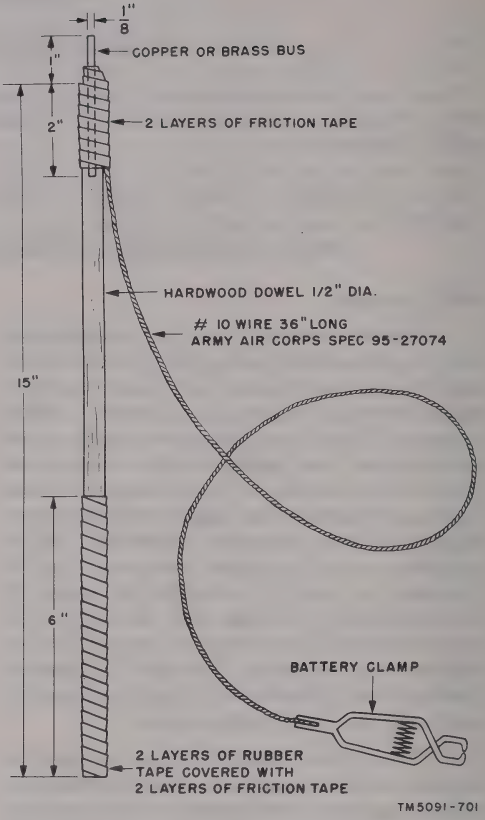


Figure 173. Shorting stick.

c. Use.

(1) Connect the battery cable to a known chassis ground as close to a capacitor as possible.

(2) Hold the shorting stick by the insulated handle and touch the capacitor terminals with the exposed bus wire.

149. Voltage Measurements

Voltage measurements are an indispensable aid to the repairman, because most troubles either result from abnormal voltages or produce abnormal voltages. Voltage measurements can be made without interrupting the circuit.

a. Complete information on the normal operating voltages of each component is given in the trouble-shooting sections. Unless otherwise specified, these voltages are measured between the points indicated and a ground point on the chassis.

b. Always begin by setting the voltmeter at the highest range, so that it will not be overloaded. If necessary, set the voltmeter to a lower range.

c. When checking cathode voltage, remember that a reading can be obtained even when the cathode resistor is open. The resistance of the meter may act as a cathode resistor. The cathode voltage, therefore, may be approximately normal only as long as the voltmeter is connected between cathode and ground.

150. Precautions Against High Voltages

Certain precautions must be followed when voltages above a few hundred volts are being measured. *High voltages are dangerous and can be fatal.* To measure high voltages, observe the following rules:

a. Connect the ground lead to the voltmeter.

b. If the voltage is known to be less than 300 volts, connect the test lead to the hot terminal, which may be either positive or negative with respect to ground.

c. If the voltage is greater than 300 volts, shut off the power, connect the hot test lead, step away from the voltmeter, turn on the power, and note the reading on the voltmeter. Do not touch any part of the voltmeter, particularly when measuring the voltage between two points, both of which are above ground.

151. Voltmeter Loading

It is essential for the voltmeter resistance to be at least 10 times greater than the resistance of the circuit across which the voltage is measured. If the voltmeter resistance is comparable to the circuit resistance, the voltmeter will indicate a voltage lower than the actual voltage present when the voltmeter is not in the circuits.

a. The resistance of the voltmeter on any range can be calculated by this simple rule: The resistance of the voltmeter equals the ohm-per-volt rating of the meter multipled by the full-scale range in volts. For example, the resistance of a 1,000-ohm-per-volt voltmeter on the 300-volt range is 1,000 × 300, or 300,000 ohms.

b. When a voltmeter is loading a circuit, the effect usually can be noted by comparing the voltage readings on two successive ranges. If the voltage readings on the two ranges do not agree, voltmeter loading may be excessive. The voltage reading on the higher range usually is slightly greater than that on the lower range. Use a vacuum-tube voltmeter, if available, when there is a possibility that the voltmeter will load the circuit. A vtvm input resistance is usually 10 megohms, and it will provide a minimum loading.

c. To minimize voltmeter loading in high-resistance circuits, use the highest voltmeter range. Although only a small deflection will be obtained (possibly only 5 divisions on a 100-division scale), the accuracy of the voltage measurements will be increased. The decreased loading of the voltmeter often will more than compensate for the inaccuracy that results from reading a small deflection on the scale.

d. The voltage-resistance charts in this manual are based on actual readings. If the resistance of the meter used in checking the voltage produces the same amount of loading as the meter originally used to measure the voltage, it is unnecessary to consider the effect of loading. Use Electronic Multimeter TS–505/U to insure no loadings.

152. Normal Resistance Values

When a fault develops in a circuit, its effect very often will show up as a change in the resistance values. To assist in the localization of such faults, the trouble-shooting data includes the normal terminal resistance values. These values should be measured between the indicating points and ground, unless otherwise stated. It is often desirable to measure the resistance from other points in the circuit to determine whether the particular points are normal. The normal resistance values at any point can be determined by referring to the resistance values shown in the schematic diagram or by using the color code. The capacitor and resistor color code values are given in figures 286 and 287.

153. Precautions When Measuring Resistance

a. Before making resistance measurements, turn off all power. An ohmmeter is essentially a low-range voltmeter and battery. If the ohmmeter is connected to a circuit that already has voltages across it, the needle will be deflected off-scale and the ohmmeter movement may be burned out or the needle may be bent.

b. Always discharge capacitors before making resistance measurements. This is important when checking power supplies that are disconnected from their load.

154. Correct Use of Ohmmeter Low and High Ranges

It is important to know when to use the low-resistance range and when to use the high-resistance range of an ohmmeter.

a. When checking circuit continuity, set the ohmmeter on the lowest range. If the medium or high range is used, the pointer may indicate 0 ohm although the resistance may be as high as several hundred ohms.

b. When checking high resistances or measuring the leakage resistance of capacitors or cables, use the highest range. If a low range is used in this case, the pointer will indicate infinite ohms, although the actual resistance may be less than 1 megohm. Be sure to keep fingers off the metal portions of the probe. Body leakage can give erroneous resistance measurements.

155. Parallel Resistor Connections

In a parallel circuit, the total resistance is less than the smallest resistance in the circuit. It is important to remember this when trouble shooting with the aid of a schematic diagram.

a. When a resistance is measured and the value is found to be less than that expected, study the schematic diagram carefully to be sure there are no resistances in parallel with the one that has been measured. Before replacing a resistor because of low resistance, disconnect one terminal from the circuit and measure its resistance again to be sure that the low reading does not occur because some part of the circuit is in parallel with the resistor.

b. It will not be possible to check a resistor when it has a low-voltage transformer winding connected across it. If the resistor must be checked, disconnect one terminal from the circuit before measuring its resistance.

156. Checking Resistance in Grid Circuit

When the resistance in a grid circuit is checked, a false reading may be obtained if the tube is still warm and the cathode is emitting electrons. Allow the tube to cool before checking the resistance.

157. Tolerance Values for Resistance Measurements

Tolerance means the normal difference that is expected between the rated value of the resistor and its actual value.

a. Most resistors that are used in this equipment have a tolerance of 10 per cent. For example, the grid resistor of a stage might have a rated value of 1 megohm. If the resistor is measured and found to have a value between .9 megohm and 1.1 megohms, it is considered normal. As a rule, the ordinary resistors used in circuits are not replaced unless their values are off more than 10 per cent. Some precision resistors and potentiometers are also used. The resistor color code (fig. 286) provides resistance and tolerance values.

b. The tolerance values for transformer windings are usually between 1 and 5 per cent. As a rule, suspect a transformer that shows a resistance deviating more than 5 per cent from its rated value. Always allow the transformer to cool before the resistance test is made.

158. Tube Checking

a. General. Tube failures are responsible for a large percentage of the faults that occur in the equipment. There are, however, too many tubes in this set for a trouble shooter to attempt to find a fault by indiscriminate tube changing. Do not resort to tube changing until the fault has been traced to a particular stage.

(1) When placing a new tube in a circuit, note the position of all controls before making any changes. If turning the

controls with the new tube in the circuit does not correct the abnormal condition, return the controls to their original position and put the old tube back in the circuit, unless a tube test shows that the tube is bad.

(2) When replacing a tube in a circuit, decide at once whether or not to keep the old tube. Do not change the tubes indiscriminately because the spare box will become full of tubes, the exact age and condition of which will be uncertain.

b. Use of Tube Tester. Electron Tube Tester Set TV–7/U is used to check for shorted elements, emission, and mutual conductance of small tubes. The tube tester will not test the performance of high-voltage tubes or rectifiers or some special tubes. Tube testers are useful, however, for checking receiving tubes. Results obtained from a tube tester are not always conclusive, because the conditions are not the same as those under which the tube operates in this set. Therefore, the final test of a tube must be its replacement with a tube which is known to be good. It is quicker and more reliable to replace a suspected tube with a good one than to check it with the tube tester. TM 11–5083 contains operating and maintenance instructions for Electron Tube Tester Set TV–7/U.

159. Checking Wave Forms

a. Checking wave forms is the best method for locating troubles. By the use of an oscilloscope, wave forms at various points in the equipment may be obtained. Faults can be localized rapidly by comparing the observed wave form with the actual reference wave form shown in the trouble-shooting sections.

b. Abnormal wave form indicates a fault between the point where the wave form is last normal and the point where it is observed to be abnormal. For example, if a wave form is observed to be normal at the grid of a stage and abnormal at the plate of the stage, the trouble lies in that stage. When the wave form of a circuit is found to be abnormal, replace the tube before making any further tests. If replacing the tube does not correct the wave form, place the original tube back in the socket. When a component does not give the expected wave form, the fault is not necessarily in the component. The abnormal wave form may be caused by the absence of a proper signal from another component. The point to start signal tracing a component is at the input receptacle.

160. Comparison of Wave Forms

If there is no fault in the circuit or the equipment, an actual wave form taken at a point in the equipment should closely resemble the reference wave form. Differences in shape, however, may occur for the following reasons:

a. The test leads to the oscilloscope may not be placed as they were when the reference wave forms were taken.

b. The various controls in the equipment may not be in the same positions as they were when the reference wave forms were taken. Note the conditions specified for the reference wave forms. Wave form figure references indicate sweep speed and voltage amplitude at specified points. Sweep time is controlled by the COARSE and FINE controls. The voltage amplitude should be checked against the internal oscilloscope calibration voltage. These controls and the amplitude calibration procedure are described in chapter 2.

c. The same number of cycles may be displayed.

d. The vertical or horizontal amplitudes of the reference and test patterns may not be proportional. This will produce apparent differences between the shapes of the two wave forms when there is no real difference.

e. Whether or not the wave form is regarded as abnormal will depend on the symptom accompanying the fault which is being traced. The error will be considered significant if the fault can be caused by a minor difference in wave form at the point under test. Otherwise, time should not be spent in hunting the cause of relatively minor differences between the shapes of the reference wave forms and the test wave forms.

161. Special Method of Testing Crystals and Rectifiers

a. To check germanium crystal 1N38A electrically, first unsolder one lead, and measure the forward and backward resistance of the crystal with Electronic Multimeter TS–505/U. Use the resistance scale specified below, because the resistance of the crystal depends on the voltage impressed on it. If the limits given below are not met, the crystal is defective and should be replaced.

(1) The forward resistance on the RX1 scale should be less than 100 ohms.

(2) The backward resistance on the RX10K scale should be larger than 200K.

Note. With some crystals, the backward resistance reading will start decreasing from its initial value. When this happens, reject the crystal unless the reading stabilizes above 200K.

b. To check germanium crystals 1N34A, follow the procedure described in subparagraph *a* above, but apply the following limits:

(1) 100 ohms forward resistance.

(2) 50,000 ohms backward resistance.

c. Selenium rectifiers are difficult to test properly; therefore, the simplest test is to substitute a new rectifier for a suspected one. However, always check the selenium rectifier circuit for a short circuit before replacing it with a new rectifier.

Caution: The vapors released by a burned-out selenium rectifier are poisonous. Do not come in contact with these vapors. Wait until the room has been thoroughly aired. Avoid touching the burned-out section of the selenium rectifiers with bare hands.

162. Test Procedure

The procedures outlined in chapter 4 should be carried out before proceeding to the field maintenance procedures in chapter 7. Because this equipment is complicated, a specific test sequence should always be followed unless the personnel is completely familiar with servicing the multiplexer group. The test sequence is as follows:

a. Perform the test procedures of chapter 4.

b. Check resistances and voltages of the suspected component.

c. Check the trouble-shooting charts.

d. If a major repair or rebuilding of the equipment has taken place, refer to the final tests, which are primarily included as a reference for unusual trouble.

Section II. TROUBLE SHOOTING VIDEO RESTORER

163. Video Restorer Trouble-shooting Data

The following data will assist maintenance personnel in trouble-shooting the video restorer unit.

Fig. No.	Description
111	Video restorer, block diagram.
260	Video restorer, schematic diagram.
275	Video restorer, wiring diagram.
174	Video restorer, top view.
175	Video restorer, bottom view, resistors.
176	Video restorer, bottom view, capacitors.
177	Video restorer, bottom view, all components except resistors and capacitors.
178	Video restorer, rear view.
179	Video restorer, tube socket voltage and resistance diagram.

164. Test Equipment Required for Video Restorer

The following test equipment is required for alignment and trouble shooting the video restorer:

a. One Multiplexer Group AN/TCA–1.

b. A source of 23-channel pulse train: .5 volt base line to peak; .6 usec nominal width at 50 per cent amplitude.

c. A source of 45-channel pulse train: 1 volt peak to peak, consisting of a 23-channel positive pulse train and a 23-channel negative pulse train, each .5 volt base line to peak; .6 volt nominal width at the 50 per cent amplitude point. The spacing in time between the leading edges of the second pulse of the positive marker and the second pulse of the negative marker should be 2.6 usec.

d. One Electronic Multimeter TS–505/U.

e. One Multimeter TS–352/U.

165. Video Restorer Trouble-shooting Procedure

a. The best means of trouble shooting this unit is by wave form comparison. Abnormal wave form indicates a fault located between the point where the wave form is last normal and the point where it is observed to be abnormal. The wave form comparison procedure in chapter 4 permits localization of a trouble to a particular stage. The wave form comparison procedures described in this chapter permit localization of the trouble to the defective part in the stage. Always complete the procedures in chapter 4 before proceeding to those of this chapter.

b. The oscilloscope is synchronized by a signal from the video restorer through SCOPE SYNC jack J10. If this signal is normal, it is an indication that stages V19 through V27 of the video restorer are operating properly. Insufficient sync voltage at jack J10 indicates that the trouble probably is in these stages.

166. Video Restorer Tube Socket Voltages and Resistances

Figure 179 shows the normal voltages between each tube socket and the chassis ground as measured by a vacuum-tube voltmeter. The values given are typical for normal operation and may vary by ±10 per cent. The B+ supply is 260 volts dc. The diagram also gives the normal resistance in ohms between each tube socket terminal and the chassis ground as calculated. For long drift capacitive circuits, sufficient time was allowed for the readings to be stabilized.

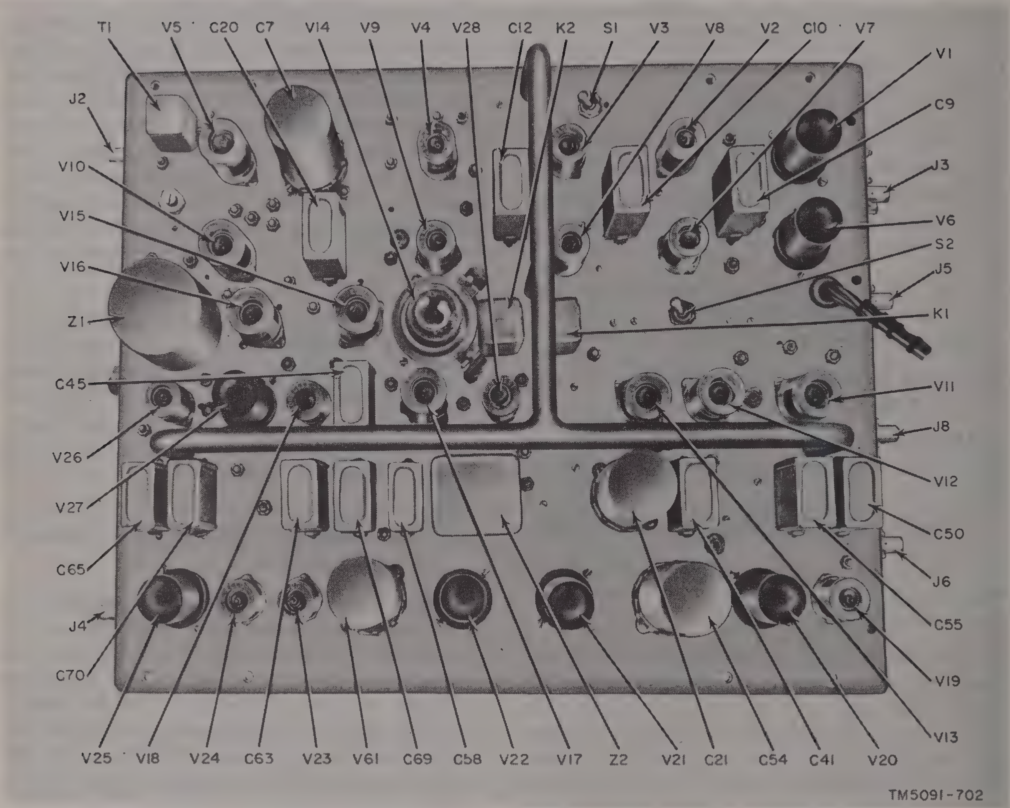

T1
V5
C20
C7
V14
V9
V4
V28
C12
K2
S1
V3
V8
V2
C10
V7
V1
C9
J3
V6
S2
J5
K1
V11
J8
V12
C50
J6
C55
V19
V13
J2
V10
V15
V16
Z1
C45
V26
V27
C65
J4
C70
V25
V18
V24
C63
V23
V61
C69
C58
V22
V17
Z2
V21
C21
C54
C41
V20
TM5091-702

Figure 174. Video restorer, top view.

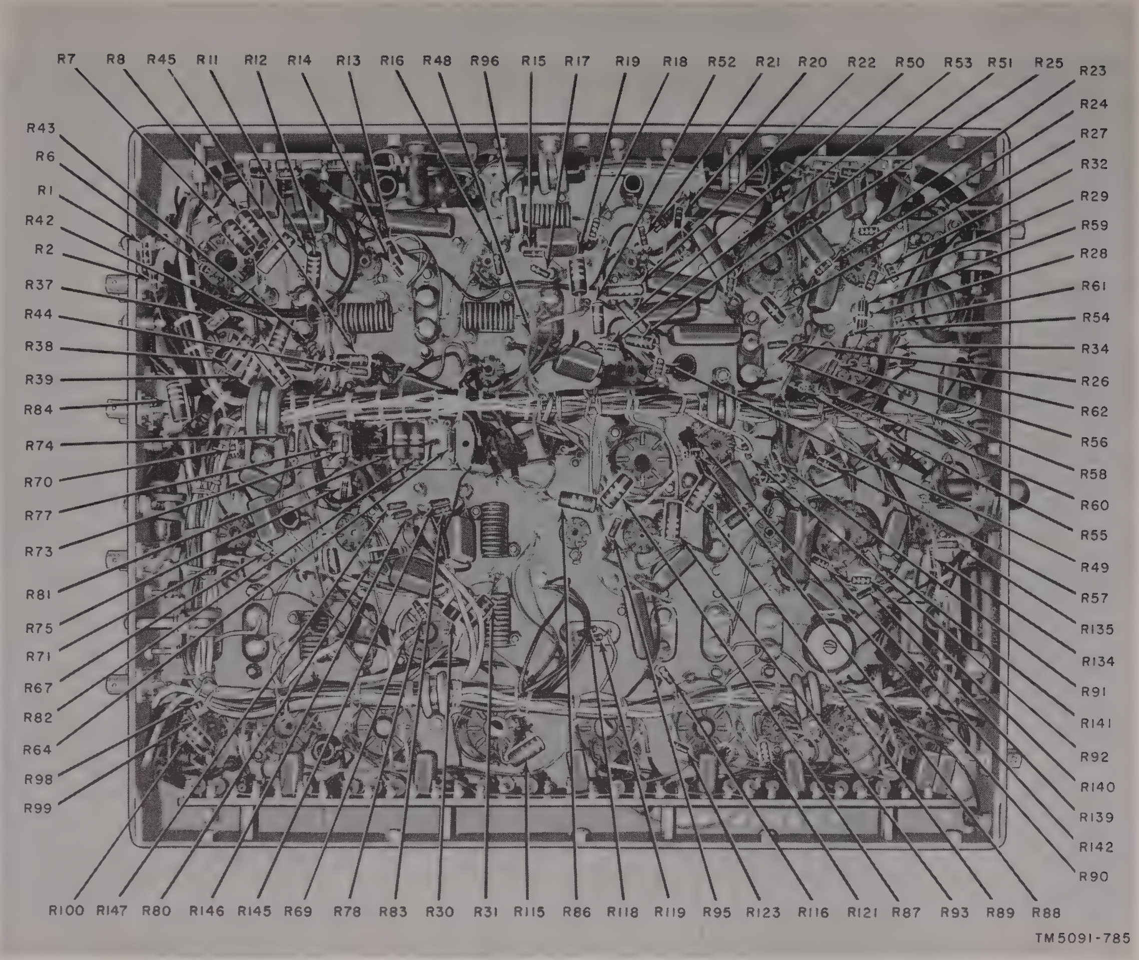

R7
R8
R45
R11
R12
R14
R13
R16
R48
R96
R15
R17
R19
R18
R52
R21
R20
R22
R50
R53
R51
R25
R23
R24
R27
R32
R29
R59
R28
R61
R54
R34
R26
R62
R56
R58
R60
R55
R49
R57
R135
R134
R91
R141
R92
R140
R139
R142
R90
R43
R6
R1
R42
R2
R37
R44
R38
R39
R84
R74
R70
R77
R73
R81
R75
R71
R67
R82
R64
R98
R99
R100
R147
R80
R146
R145
R69
R78
R83
R30
R31
R115
R86
R118
R119
R95
R123
R116
R121
R87
R93
R89
R88
TM5091-785

Figure 175. Video restorer, bottom view, resistors.

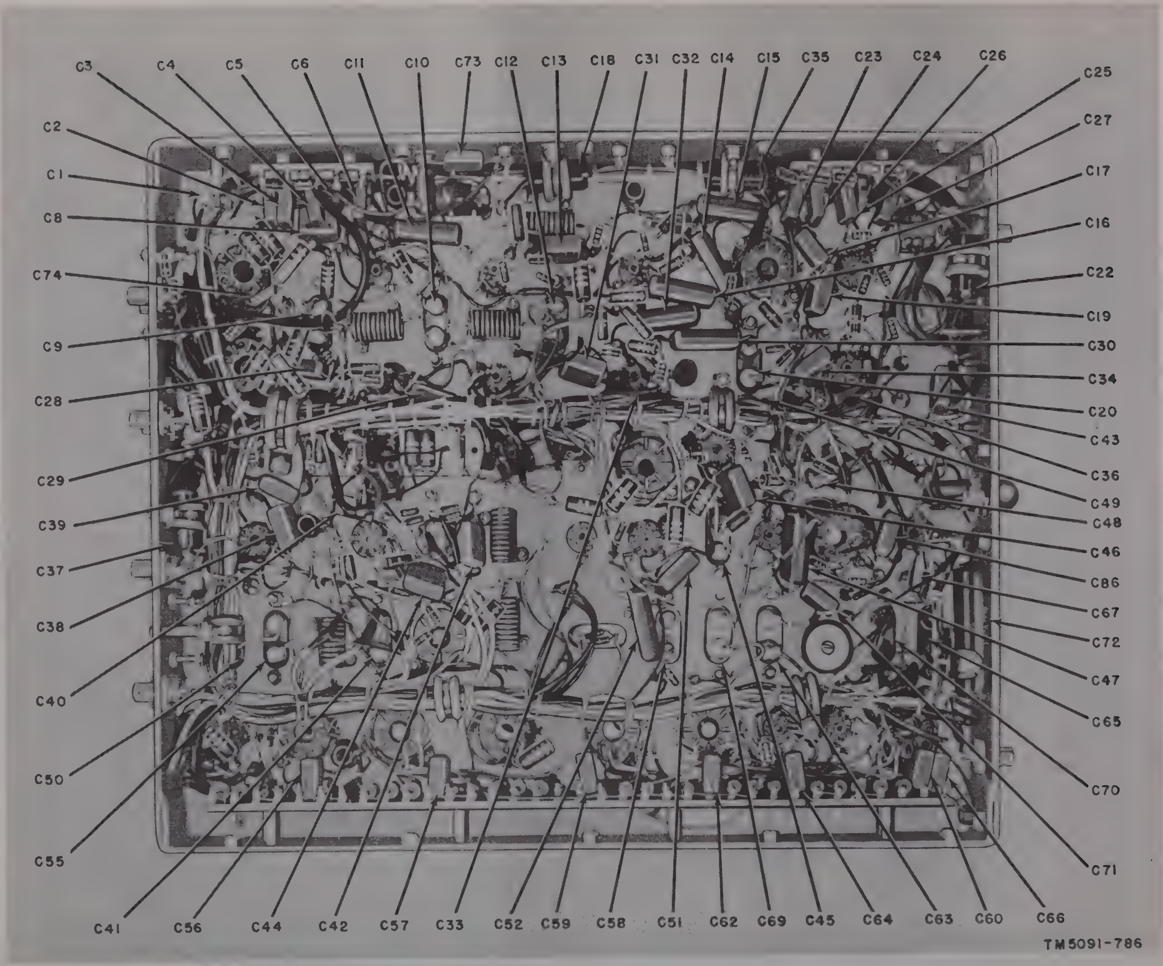

C3
C4
C5
C6
C11
C10
C73
C12
C13
C18
C31
C32
C14
C15
C35
C23
C24
C26
C2
C1
C8
C74
C9
C28
C29
C39
C37
C38
C40
C50
C55
C25
C27
C17
C16
C22
C19
C30
C34
C20
C43
C36
C49
C48
C46
C86
C67
C72
C47
C65
C70
C71
C41
C56
C44
C42
C57
C33
C52
C59
C58
C51
C62
C69
C45
C64
C63
C60
C66
TM5091-786

Figure 176. Video restorer, bottom view, capacitors.

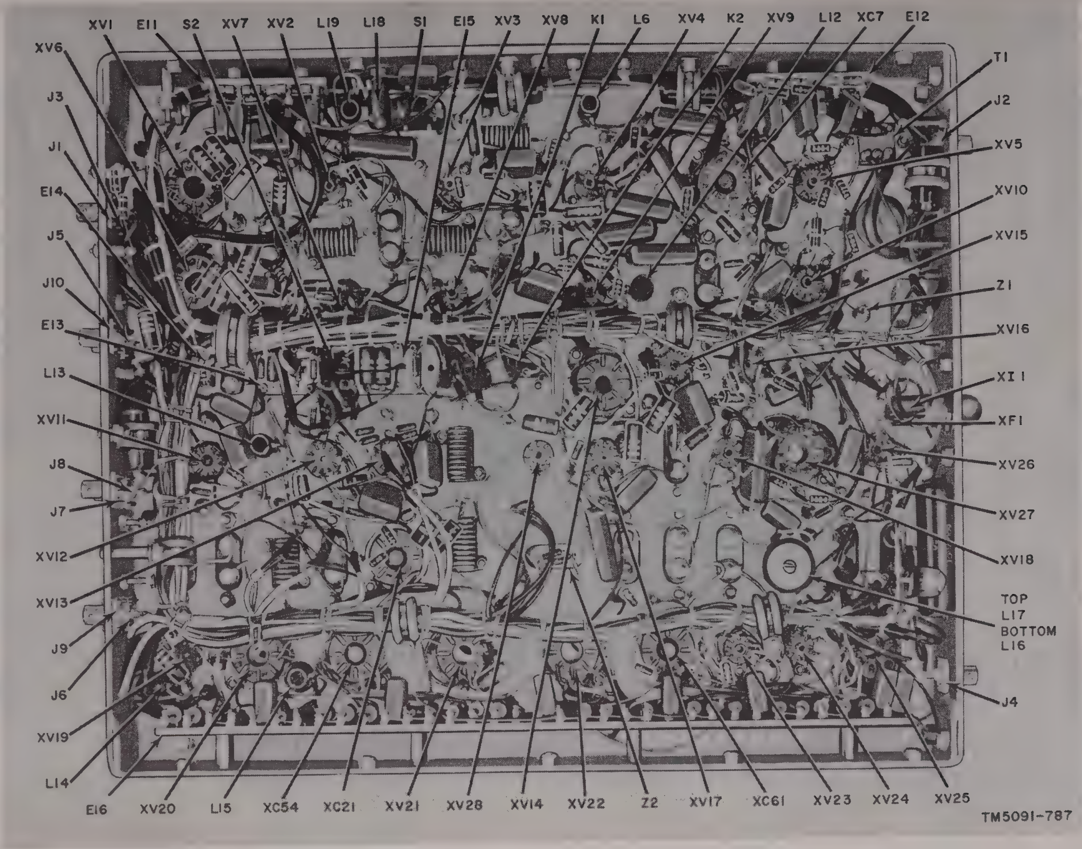

XV1
E11
S2
XV7
XV2
L19
L18
S1
E15
XV3
XV8
K1
L6
XV4
K2
XV9
L12
XC7
E12
XV6
J3
J1
E14
J5
J10
E13
L13
XV11
J8
J7
XV12
XV13
J9
J6
XV19
L14
T1
J2
XV5
XV10
XV15
Z1
XV16
XI 1
XF1
XV26
XV27
XV18
TOP
L17
BOTTOM
L16
J4
E16
XV20
L15
XC54
XC21
XV21
XV28
XV14
XV22
Z2
XV17
XC61
XV23
XV24
XV25
TM5091-787

Figure 177. Video restorer, bottom view, all components except resistors and capacitors.

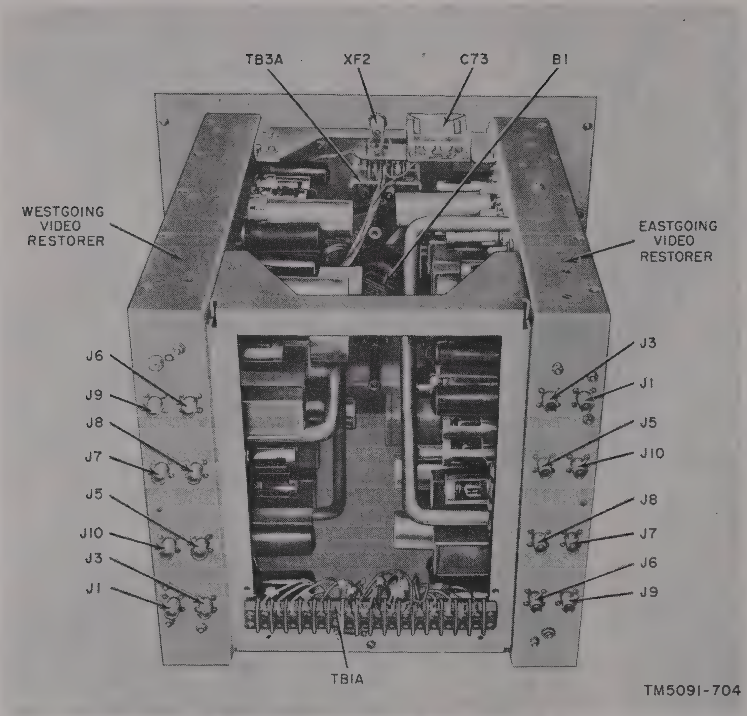
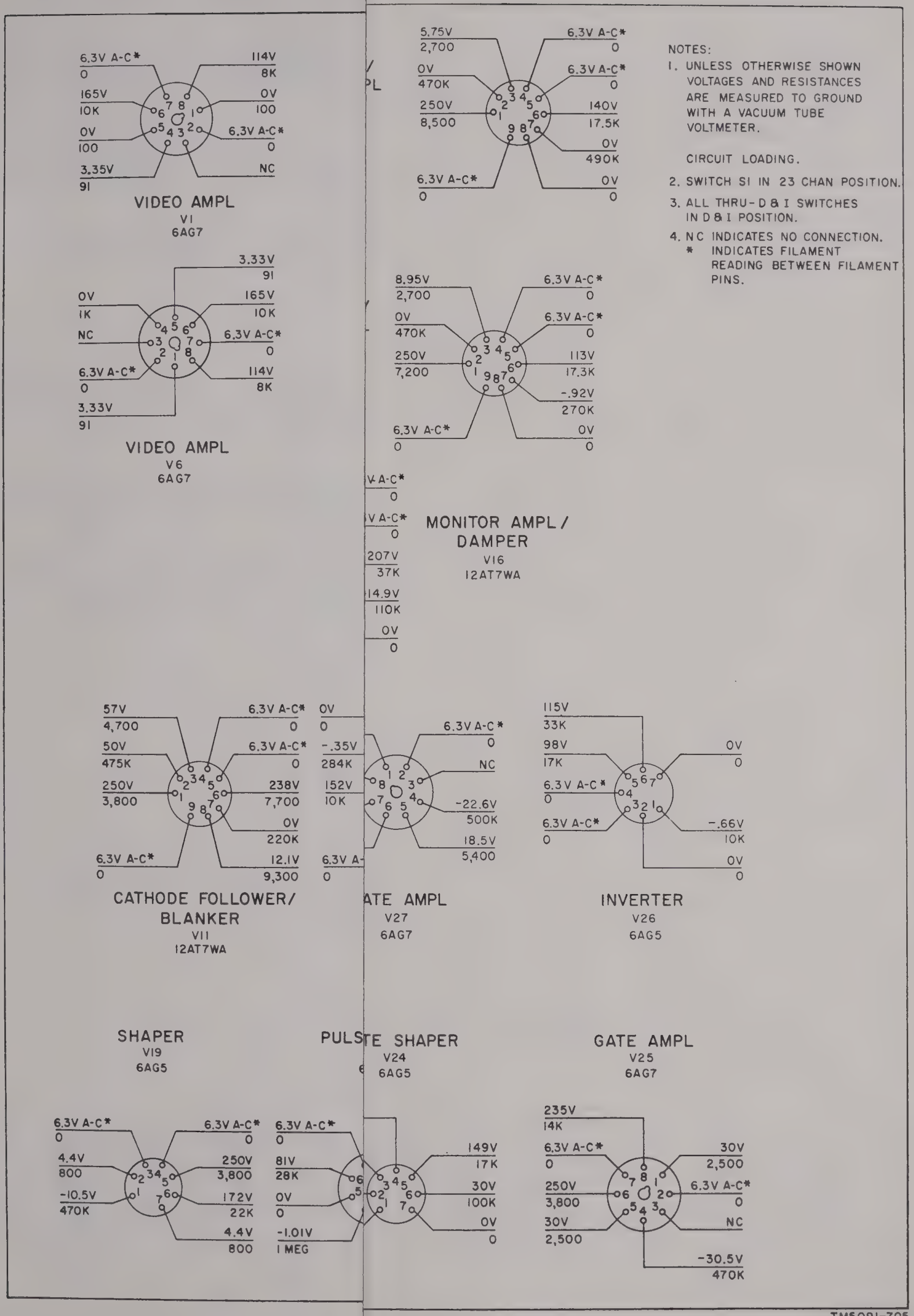

TB3A
XF2
C73
B1
WESTGOING VIDEO RESTORER
EASTGOING VIDEO RESTORER
J6
J9
J8
J7
J5
J10
J3
J1
J3
J1
J5
J10
J8
J7
J6
J9
TB1A
TM5091-704

Figure 178. Video restorer, rear view.


VIDEO AMPL
V1
6AG7
VIDEO AMPL
V6
6AG7
MONITOR AMPL / DAMPER
V16
12AT7WA
CATHODE FOLLOWER/ BLANKER
V11
12AT7WA
ATE AMPL
V27
6AG7
INVERTER
V26
6AG5
SHAPER
V19
6AG5
PULSTE SHAPER
V24
6AG5
GATE AMPL
V25
6AG7
6.3V A-C*
NC
TM5091-705

NOTES:

1. UNLESS OTHERWISE SHOWN VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A VACUUM TUBE VOLTMETER.

   CIRCUIT LOADING.

2. SWITCH S1 IN 23 CHAN POSITION.
3. ALL THRU-D & I SWITCHES IN D & I POSITION.
4. NC INDICATES NO CONNECTION.
   * INDICATES FILAMENT READING BETWEEN FILAMENT PINS.

Figure 179. Video restorer, tube socket voltage and resistance diagram.

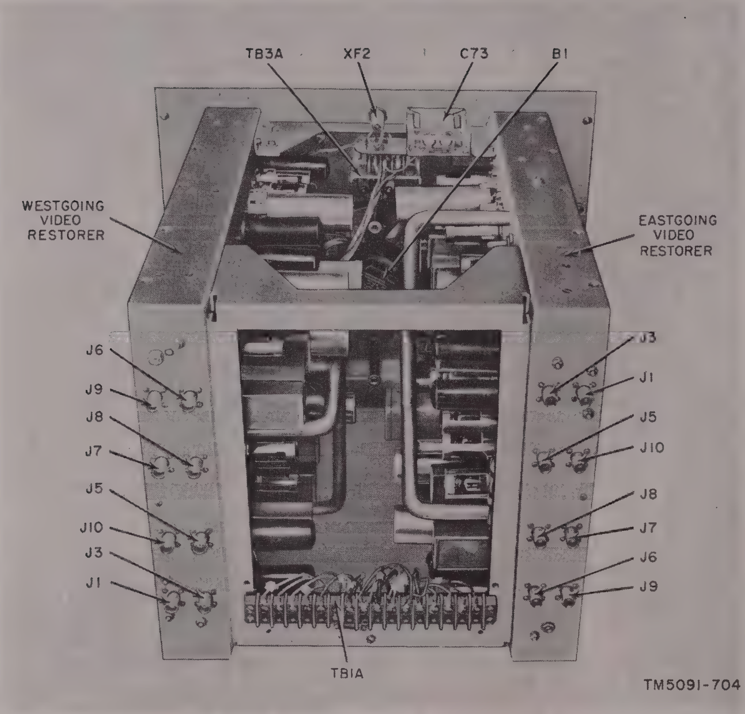
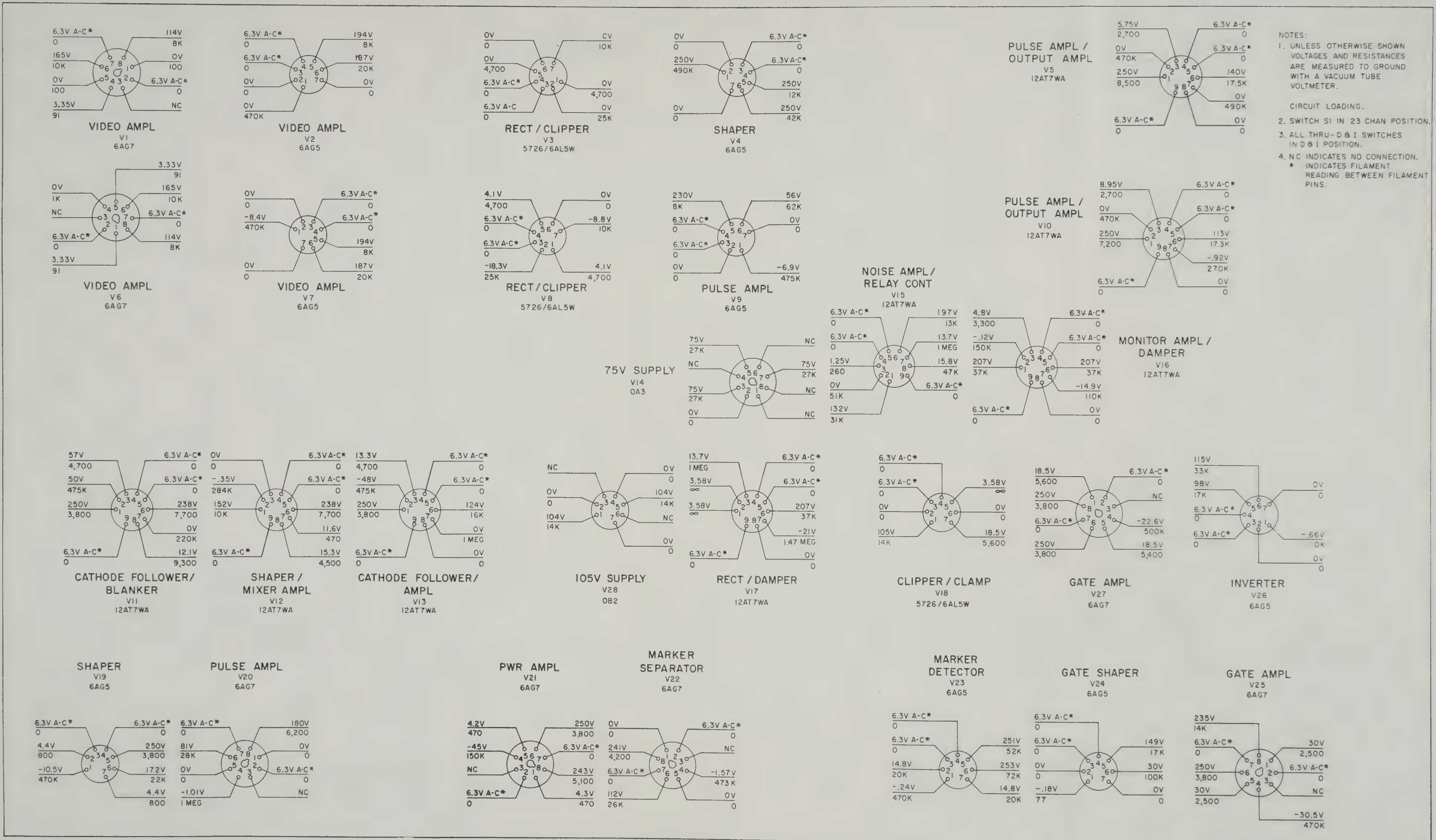

TB3A
XF2
C73
B1
WESTGOING VIDEO RESTORER
EASTGOING VIDEO RESTORER
J6
J9
J8
J7
J5
J10
J3
J1
J3
J1
J5
J10
J8
J7
J6
J9
TB1A
TM5091-704

Figure 178. Video restorer, rear view.


VIDEO AMPL V1 6AG7
VIDEO AMPL V2 6AG5
RECT / CLIPPER V3 5726/6AL5W
SHAPER V4 6AG5
PULSE AMPL / OUTPUT AMPL V5 12AT7WA
VIDEO AMPL V6 6AG7
VIDEO AMPL V7 6AG5
RECT / CLIPPER V8 5726/6AL5W
PULSE AMPL V9 6AG5
PULSE AMPL / OUTPUT AMPL V10 12AT7WA
NOISE AMPL / RELAY CONT V15 12AT7WA
75V SUPPLY V14 0A3
MONITOR AMPL / DAMPER V16 12AT7WA
CATHODE FOLLOWER / BLANKER V11 12AT7WA
SHAPER / MIXER AMPL V12 12AT7WA
CATHODE FOLLOWER / AMPL V13 12AT7WA
105V SUPPLY V28 0B2
RECT / DAMPER V17 12AT7WA
CLIPPER / CLAMP V18 5726/6AL5W
GATE AMPL V27 6AG7
INVERTER V26 6AG5
SHAPER V19 6AG5
PULSE AMPL V20 6AG7
PWR AMPL V21 6AG7
MARKER SEPARATOR V22 6AG7
MARKER DETECTOR V23 6AG5
GATE SHAPER V24 6AG5
GATE AMPL V25 6AG7

NOTES:

1. UNLESS OTHERWISE SHOWN VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A VACUUM TUBE VOLTMETER.

   CIRCUIT LOADING.

2. SWITCH S1 IN 23 CHAN POSITION.
3. ALL THRU-D & I SWITCHES IN D & I POSITION.
4. NC INDICATES NO CONNECTION.

   * INDICATES FILAMENT READING BETWEEN FILAMENT PINS.

TM5091-705

Figure 179. Video restorer, tube socket voltage and resistance diagram.

167. Video Restorer Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the video restorer. This chart lists the symptoms (some of which the repairman observes either visually or audibly while making a few tests), the probable trouble, and the procedure for remedying the trouble. It is supplementary to the equipment performance checklist (par. 97).

Symptom	Probable trouble	Correction
1. No B+ voltage.	1. Short circuit from B+ to ground. Blown +250V fuse.	1. Locate and remove short. Replace B+ fuse (F1).
2. No filament voltage.	2. Short circuit across filament leads. Blown filament fuses.	2. Locate and remove short. Replace filament fuses on multiplexer subassembly. Fuse F5 or F6, FIL RIGHT SIDE; fuse F7 or F8, FIL LEFT SIDE.
3. Fan does not turn.	3. Blown fan fuse.	3. Replace fan fuse (F2).
4. Fan turns in wrong direction.	4. Fan wiring incorrect.	4. Rewire fan correctly.
5. No pulse train at INPUT FROM REC test point (E1).	5. No pulse train from r-f receiver. Faulty video connection from r-f receiver to video restorer.	5. Check r-f receiver output. Replace interconnecting cord, CG–409C/CU.
6. No gate at the DEMTPX GATE test point (E5).	6. No input pulse train.	6. Perform step 5 above.
	Faulty input filter. If filter is open, there will be no pulse train at pin 5 of V6.	Replace faulty 1-mc filter.
	Coil L11 open in plate of V6. If L11 is open, there will be no pulse train at pin 5 of V6.	Replace L11.
	Coil L12 open in plate of V9. If L12 is open, there will be no pulse train at pin 5 of V9.	Replace L12.
	Coil L15 open in the decoupling circuit of V19. If L15 is open, there will be no pulse train at pin 5 of V19.	Replace L15.
7. Waveshape at DEMTPX GATE test point (E5) improper.	7. Coil L14 open. If L14 is open, the channel pulses at pin 4 of V20 will be very wide.	7. Replace L14.
	Delay line Z2 in plate of V22 faulty. If Z2 is faulty, the waveshape is proper at pin 4 of V22, but improper at pin 8 of V22.	Replace Z2.
	Coil L16 open. If L16 is open, the waveshape at pin 1 of V24 is improper.	Replace L16.
	Delay line with an open or shorted section.	Repair faulty section (par. 180).
8. *All* blanking gates missing at the BLANKING GATE test point (E4) (with all channels in D&I and channels 1 and 2 in NORMAL OPERATION).	8. No demultiplexer gate. Faulty connection from DEMTPX delay line to J6 of the video restorer. If the connection is faulty, there will be no gates at J6 of the video restorer.	8. Refer to step 6 above. Replace faulty connection.

Symptom	Probable trouble	Correction
9. A channel blanking gate missing at the BLANKING GATE test point (E4).	9. Faulty connection from the DEMTPX delay line to the D&I-THRU plug or from the plug to J6 on the video restorer.	9. Replace the faulty connection.
10. Waveshapes improper at the BLANKING GATE test point (E4).	10. Blanking gates misaligned.	10. Refer to blanking gate alignment procedure. (par. 218*b*(7)).
11. No gate at the MTPX GATE test point (E6).	11. No demultiplexer gate or improper demultiplexer gate.	11. Refer to steps 6 and 7 above.
12. Waveshape at MTPX gate test point improper.	12. Improper demultiplexer gate.	12. Refer to step 7 above.
	Capacitor C67 open if gate is too narrow.	Replace C67.
	MTPX delay line section open or shorted.	Repair the faulty section (par. 180).
13. *All* channel pulses missing at MODEM CHAN PULSES test point (E3). (*All* channels in D&I and channels 1 and 2 in NORMAL OPERATION.)	13. No multiplexer gate or improper waveshape.	13. Refer to steps 6, 7, and 12 above.
	Faulty connection between the modem common cathode (pin K on modem plug) and J3 at the video restorer.	Repair faulty connection.
14. A channel pulse missing at the MODEM CHAN PULSES test point. (*All* channels in D&I and channels 1 and 2 in NORMAL OPERATION.)	14. Faulty connection from modem pin K to common cathode cable.	14. Repair faulty connection.
	Faulty connection from MTPX delay line to D&I-THRU plug or from the plug to pin C on the modem.	Repair faulty connection.
	Faulty modem.	Refer to section III of this chapter.
15. No inserted pulses at the OUTPUT TO XMTR test point (E2). (*All* channels in D&I and channels 1 and 2 in NORMAL OPERATION.)	15. No pulses at MODEM CHAN PULSES test point (E3).	15. Refer to steps 13 and 14 above.
	Coil L13 open. If L13 is open, there will be no pulse train at pin 1 of V12.	Replace L13.
	Faulty 1-mc output filter. Filter faulty if there is a pulse train into the filter but no output from it.	Replace filter.
	Faulty contacts on relay K1.	Replace K1.
	Transformer T1 faulty.	Replace T1.
16. Pulses at the OUTPUT TO XMTR test point too wide.	16. Coil L13 open in plate of V12.	16. Replace L13.
	Crystal CR3 or CR4 faulty.	Replace faulty crystal.
17. In 45-channel operation, no negative pulse train at the OUTPUT TO XMTR test point.	17. No 45-channel pulse train at INPUT FROM REC test point.	17. Refer to step 5 above.
	Coil L5 open in plate of V1. If L5 is open, there will be no pulse train at pin 8 of V1.	Replace L5.
	Switch S1 open.	Replace S1.
18. In 45-channel operation, negative pulses at the OUTPUT TO XMTR test point, too wide.	18. Coil L6 open in the plate of V4.	18. Replace L6.
	Crystal CR1 or CR2 faulty.	Replace the faulty crystal.
19. Alarm is activated.	19. No B+ or filament voltage.	19. Refer to steps 1 and 2 above.
	No gate at pin 7 of V17.	Refer to steps 6 and 7 above.
	No pulse train at pin 2 of V16.	Refer to steps 1 and 2 above.
	Crystal CR5 or CR6 faulty.	Replace faulty relay.
	Relays K1 or K2 faulty.	Replace faulty crystal.

168. Video Restorer Tests

The following tests should be used as a complete operational check after major repairs at a Signal Depot or at a General Depot. For any normal tests, just check the resistance, voltage and wave forms.

a. 23-channel Operation.

(1) Wave forms.
(2) Alarm circuit.
(3) Voltage regulator tube voltages.
(4) Fan rotation.

b. 45-channel Operation.

(1) Wave forms.
(2) Symmetry control.

169. Video Restorer Test Procedures

a. General. Both sections of the video restorer are identical; therefore, these procedures may be used to test either. The equipment to be tested should be connected to Multiplexer Group AN/TCA-1 as shown in figure 180. Throw 23 CHAN-45 CHAN switch S1 to the 23 CHAN position to disconnect the filaments of V1 through V5 from the filament supply. Place P.T. OUT AMPL switch S2 in the LOW position. Place all D&I-THRU switches on Electrical Equipment Rack MT-1433/TCA-1 in the D&I position and connect the 23-channel pulse train source (.5 volt) to J11 (INPUT FROM EASTFACING REC) or J14 (INPUT FROM WESTFACING REC), depending on which side of Pulse Form Restorer TD-68/G is to be tested.

(1) *Wave forms.* The wave forms listed below should be measured and should not vary by more than 25 per cent in amplitude and width from the referenced figure.

Measure point	Fig. ref
Pin 8 of V11B	62
Pin 3 of V13A	62
E4	62
Pin 8 of V22	83
Pin 1 of V23	83
Pin 8 of V25	61
J8	61
E5	61
Pin 5 of V27	63
Pin 7 of V18A	63
J9	63
E6	63

(2) *Alarm circuit.*

(*a*) With a pulse train connected to video restorer INPUT FROM RF jack J1, ALARM indicator I 1 on the video restorer panel should not light, and AUDIBLE ALARM buzzer I 1 in the mounting rack should not sound. The indicator will light and the buzzer will sound if the pulse train input cable is removed from the video restorer; if the marker-separator and gate shaping sections, V19 through V26, fail or operate improperly; the positive pulse train section, V6 through V12, fails or operates improperly; or if the supply fails.

(*b*) When any of these conditions in subparagraph (*a*) above occur, the alarm relay should operate and bypass INPUT FROM RF pulse train jack J1 to OUTPUT TO RF jack J3, where it may be observed. The pulse train seen at OUTPUT TO WESTFACING XMTR test point E2 will be attenuated by the 6-db pad, consisting of resistors R1, R2, and R3.

(*c*) At the same time that the signal is bypassed, the alarm relay removes the ringing 250 volts dc on terminal 3 or 14 of TB1A (depending on the side being tested).

(3) *Voltage regulator tube voltages.* Measure the voltages of tubes V14 and V28. The voltage at pins 3, 5, and 7 of tube V14 should be 75 volts ±5 volts; the voltage at pins 1 and 5 of V28 should be 108 volts ±5 volts.

(4) *Fan rotation.* The fan should be turning so that air is sucked in the front of the video restorer.

b. 45-channel Operation.

(1) *General.* Connect a 45-channel pulse train source (1 volt nominal peak to peak) to J11 or J14 (fig. 181). This wave train should consist of both a positive 23-channel pulse train and a negative 23-channel train, each being at least .5 volt from the base line to peak. Throw the 23 CHAN-45 CHAN switch to the 45 CHAN position, thus energizing the filaments of V1 through V5. All other conditions remain the same as for 23-channel operation tests.

(2) *Wave forms.* The following wave forms should not vary by more than 25 per cent in amplitude and width from the referenced figure.

Measure point	Fig. ref
J3 (OUTPUT TO RF), with direct probe	60
J4 (OUTPUT TO EASTFACING XMTR), with direct probe	60

(3) *Symmetry adjust control.* With the scope probe on J4, adjust the SYM ADJ control (R33) so that both the positive and negative pulse train are of the same amplitude. They should measure .8 to 1.1 volts from base line to peak with P.T. OUT AMPL switch S2 in the HIGH position. When the switch is in the LOW position, the value should be from .4 to .6 volt.

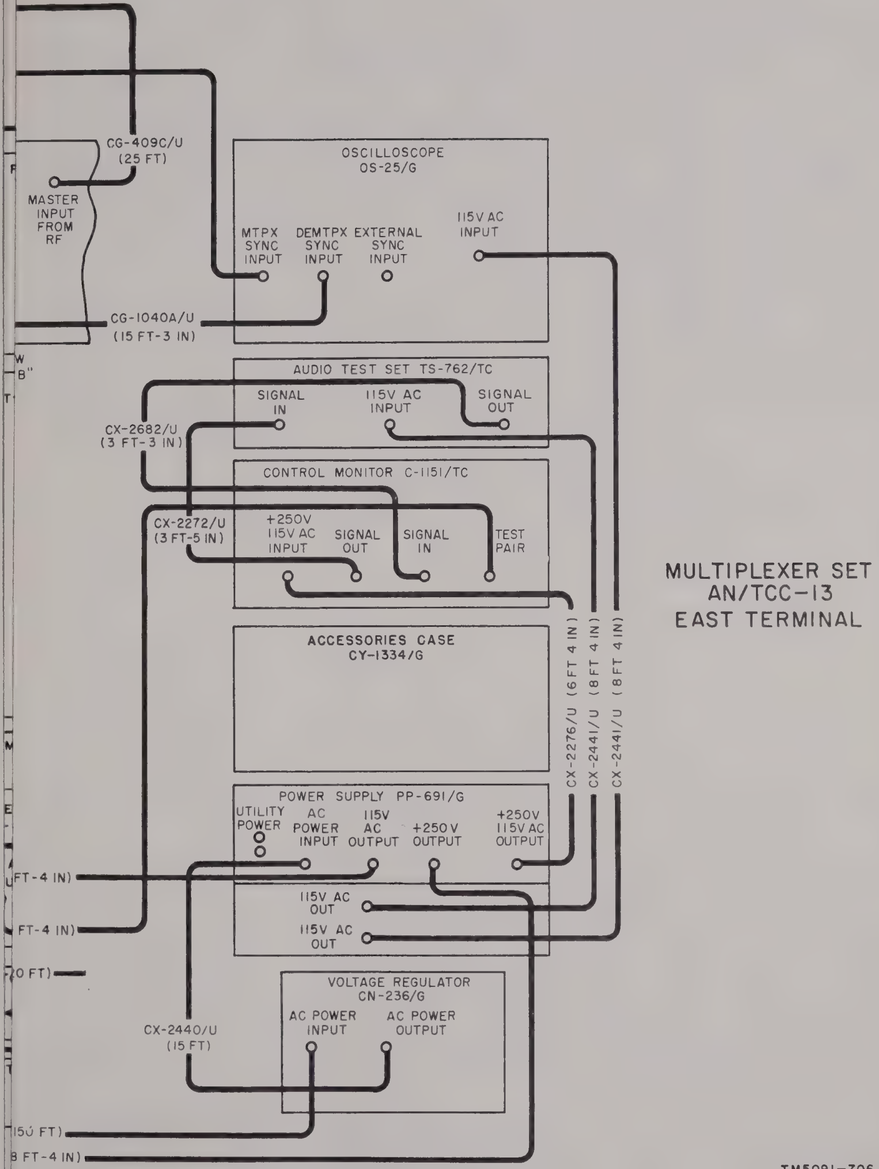

CG-409C/U
(25 FT)
MASTER INPUT FROM RF
CG-1040A/U
(15 FT-3 IN)
OSCILLOSCOPE
OS-25/G
MTPX SYNC INPUT
DEMTPX SYNC INPUT
EXTERNAL SYNC INPUT
115V AC INPUT
AUDIO TEST SET TS-762/TC
SIGNAL IN
115V AC INPUT
SIGNAL OUT
CX-2682/U
(3 FT-3 IN)
CONTROL MONITOR C-1151/TC
CX-2272/U
(3 FT-5 IN)
+250V 115V AC INPUT
SIGNAL OUT
SIGNAL IN
TEST PAIR
ACCESSORIES CASE
CY-1334/G
CX-2276/U (6 FT 4 IN)
CX-2441/U (8 FT 4 IN)
CX-2441/U (8 FT 4 IN)
MULTIPLEXER SET
AN/TCC-13
EAST TERMINAL
POWER SUPPLY PP-691/G
UTILITY POWER
AC POWER INPUT
115V AC OUTPUT
+250V OUTPUT
+250V 115V AC OUTPUT
115V AC OUT
115V AC OUT
FT-4 IN)
FT-4 IN)
0 FT)
VOLTAGE REGULATOR
CN-236/G
AC POWER INPUT
AC POWER OUTPUT
CX-2440/U
(15 FT)
150 FT)
8 FT-4 IN)
W
B"
T
M
E
U
TM5091-706

Figure 180. Test set-up, using Multiplexer Group AN/TCA-1 (23-channel operation).

b. 45-channel Operation.

(1) *General.* Connect a 45-channel pulse train source (1 volt nominal peak to peak) to J11 or J14 (fig. 181). This wave train should consist of both a positive 23-channel pulse train and a negative 23-channel train, each being at least .5 volt from the base line to peak. Throw the 23 CHAN-45 CHAN switch to the 45 CHAN position, thus energizing the filaments of V1 through V5. All other conditions remain the same as for 23-channel operation tests.

(2) *Wave forms.* The following wave forms should not vary by more than 25 per cent in amplitude and width from the referenced figure.

Measure point	Fig. ref
J3 (OUTPUT TO RF), with direct probe	60
J4 (OUTPUT TO EASTFACING XMTR), with direct probe	60

(3) *Symmetry adjust control.* With the scope probe on J4, adjust the SYM ADJ control (R33) so that both the positive and negative pulse train are of the same amplitude. They should measure .8 to 1.1 volts from base line to peak with P.T. OUT AMPL switch S2 in the HIGH position. When the switch is in the LOW position, the value should be from .4 to .6 volt.

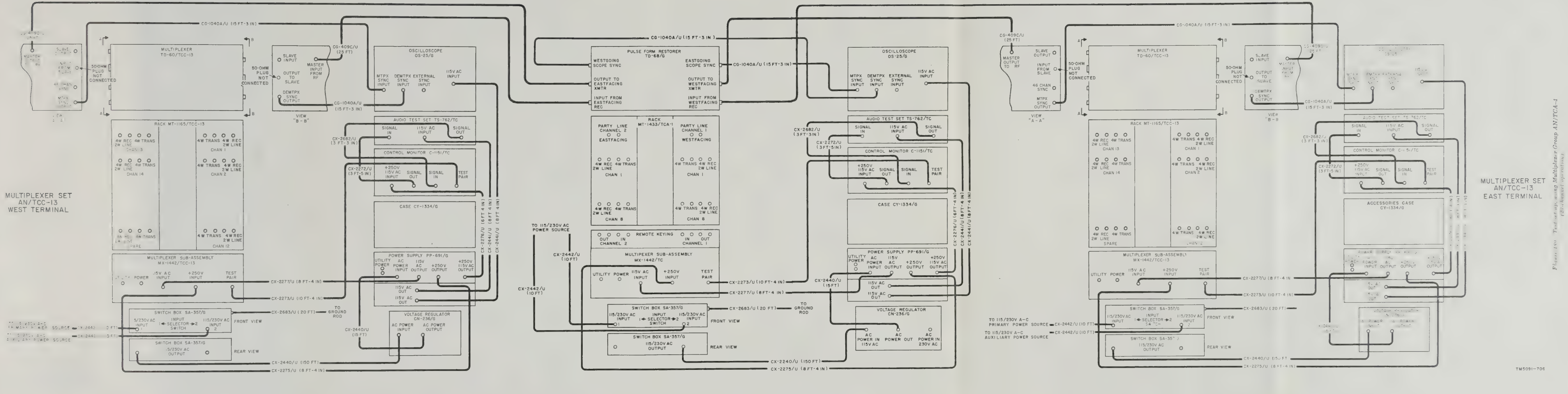

MULTIPLEXER SET
AN/TCC-13
WEST TERMINAL
MULTIPLEXER SET
AN/TCC-13
EAST TERMINAL
CG-1040A/U (15 FT-3 IN)
CG-409C/U (25 FT)
MULTIPLEXER
TD-60/TCC-13
50-OHM PLUG NOT CONNECTED
SLAVE INPUT
OUTPUT TO SLAVE
MASTER INPUT FROM RF
DEMTPX SYNC OUTPUT
VIEW "B-B"
VIEW "A-A"
OSCILLOSCOPE
OS-25/G
MTPX SYNC INPUT
DEMTPX SYNC INPUT
EXTERNAL SYNC INPUT
115V AC INPUT
PULSE FORM RESTORER
TD-68/G
WESTGOING SCOPE SYNC
EASTGOING SCOPE SYNC
OUTPUT TO EASTFACING XMTR
INPUT FROM EASTFACING REC
OUTPUT TO WESTFACING XMTR
INPUT FROM WESTFACING REC
RACK MT-1165/TCC-13
4W REC 2W LINE
4W TRANS
CHAN 1
CHAN 2
CHAN 13
CHAN 14
CHAN 12
SPARE
RACK MT-1433/TCA-1
PARTY LINE CHANNEL 2 EASTFACING
PARTY LINE CHANNEL 1 WESTFACING
CHAN 8
REMOTE KEYING
OUT IN CHANNEL 2
OUT IN CHANNEL 1
AUDIO TEST SET TS-762/TC
SIGNAL IN
115V AC INPUT
SIGNAL OUT
CX-2682/U (3 FT-3 IN)
CONTROL MONITOR C-1151/TC
CX-2272/U (3 FT-5 IN)
+250V 115V AC INPUT
SIGNAL OUT
SIGNAL IN
TEST PAIR
CASE CY-1334/G
ACCESSORIES CASE CY-1334/G
POWER SUPPLY PP-691/G
UTILITY POWER
AC POWER INPUT
115V AC OUTPUT
+250V OUTPUT
+250V 115V AC OUTPUT
115V AC OUT
CX-2276/U (6 FT-4 IN)
CX-2441/U (8 FT-4 IN)
MULTIPLEXER SUB-ASSEMBLY
MX-1442/TCC-13
MX-1442/TC
UTILITY POWER
115V AC INPUT
+250V INPUT
TEST PAIR
CX-2277/U (8 FT-4 IN)
CX-2273/U (10 FT-4 IN)
SWITCH BOX SA-357/G
115/230V AC INPUT
INPUT 1 ◄ SELECTOR ► 2 SWITCH
FRONT VIEW
REAR VIEW
115/230V AC OUTPUT
CX-2683/U (20 FT)
TO GROUND ROD
VOLTAGE REGULATOR
CN-236/G
AC POWER INPUT
AC POWER OUTPUT
AC POWER IN 115V AC
AC POWER OUT
AC POWER IN 230V AC
CX-2440/U (15 FT)
CX-2440/U (150 FT)
CX-2275/U (8 FT-4 IN)
TO 115/230V AC POWER SOURCE
CX-2442/U (10 FT)
TO 115/230V A-C PRIMARY POWER SOURCE
TO 115/230V A-C AUXILIARY POWER SOURCE
TM5091-706

Figure 150. Test set up, using Multiplexer Group AN/TCA-1 (24-channel operation)

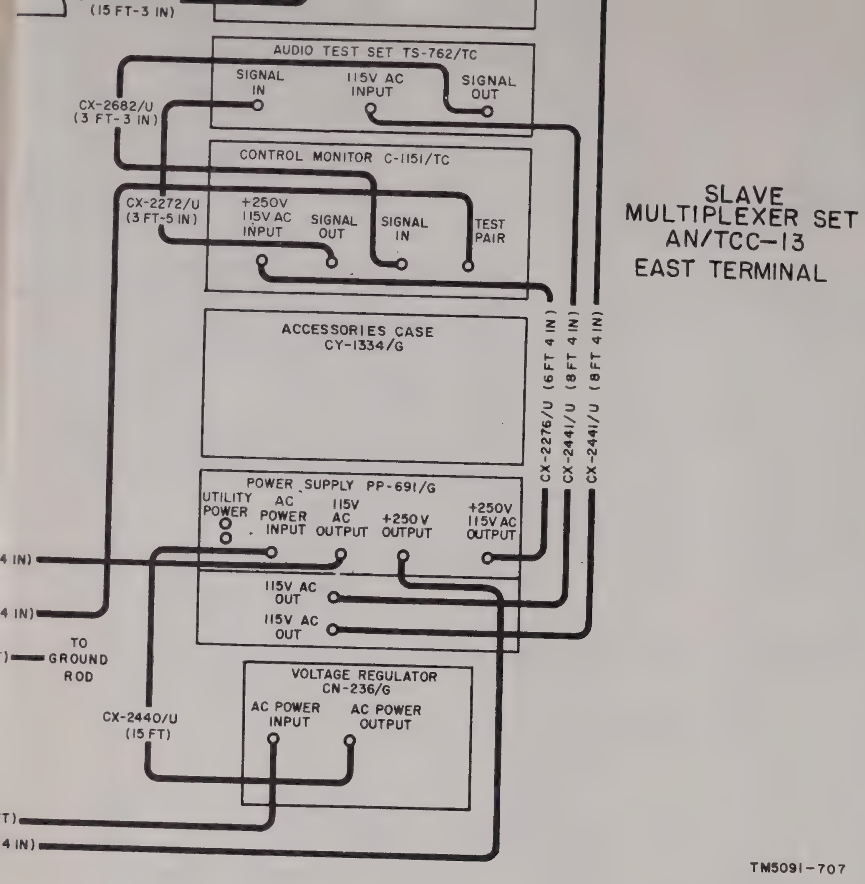

(15 FT-3 IN)
AUDIO TEST SET TS-762/TC
SIGNAL IN
115V AC INPUT
SIGNAL OUT
CX-2682/U (3 FT-3 IN)
CONTROL MONITOR C-1151/TC
CX-2272/U (3 FT-5 IN)
+250V 115V AC INPUT
SIGNAL OUT
SIGNAL IN
TEST PAIR
ACCESSORIES CASE CY-1334/G
CX-2276/U (6 FT 4 IN)
CX-2441/U (8 FT 4 IN)
CX-2441/U (8 FT 4 IN)
POWER SUPPLY PP-691/G
UTILITY POWER
AC POWER INPUT
115V AC OUTPUT
+250 V OUTPUT
+250V 115V AC OUTPUT
4 IN)
4 IN)
115V AC OUT
115V AC OUT
TO GROUND ROD
VOLTAGE REGULATOR CN-236/G
AC POWER INPUT
AC POWER OUTPUT
CX-2440/U (15 FT)
T)
4 IN)
SLAVE MULTIPLEXER SET AN/TCC-13 EAST TERMINAL
TM5091-707

Figure 181. Test set-up, using Multiplexer Group (45-channel operation).

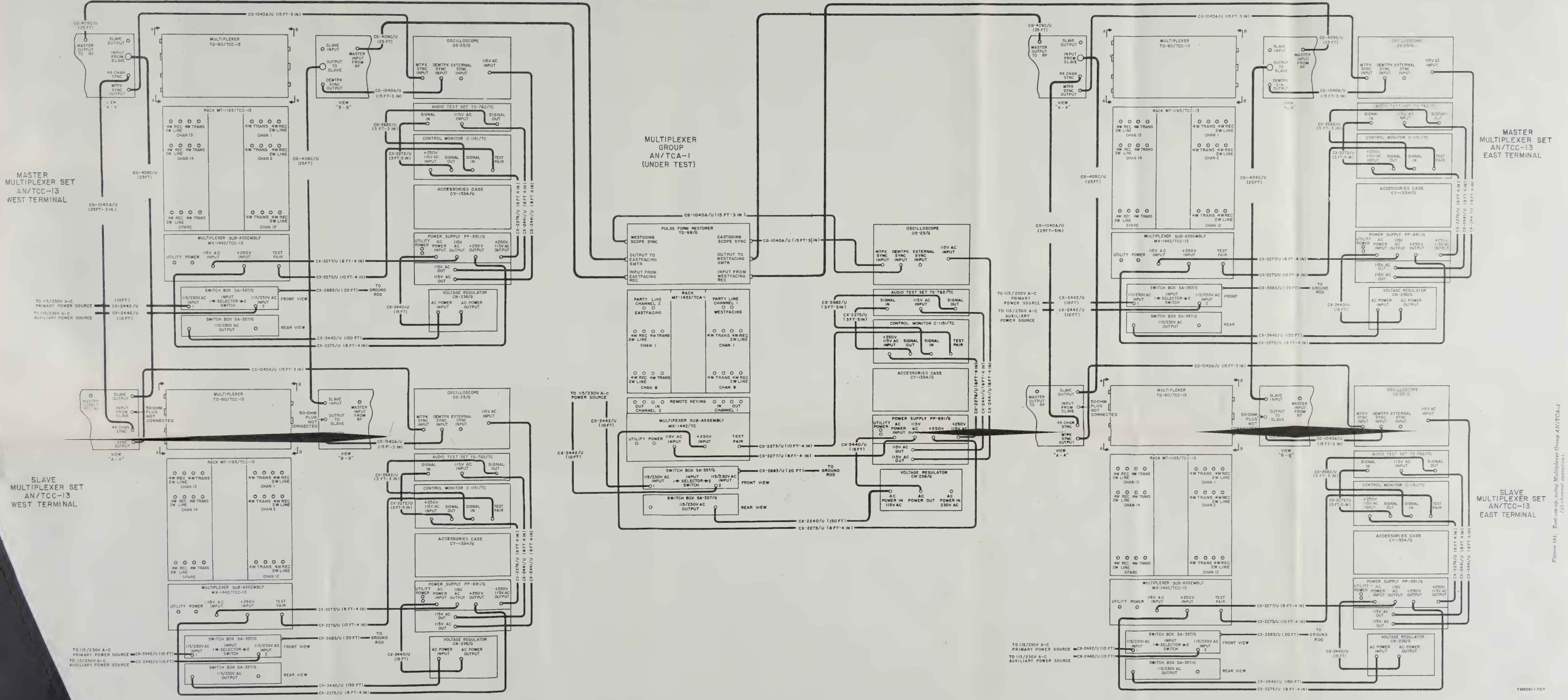
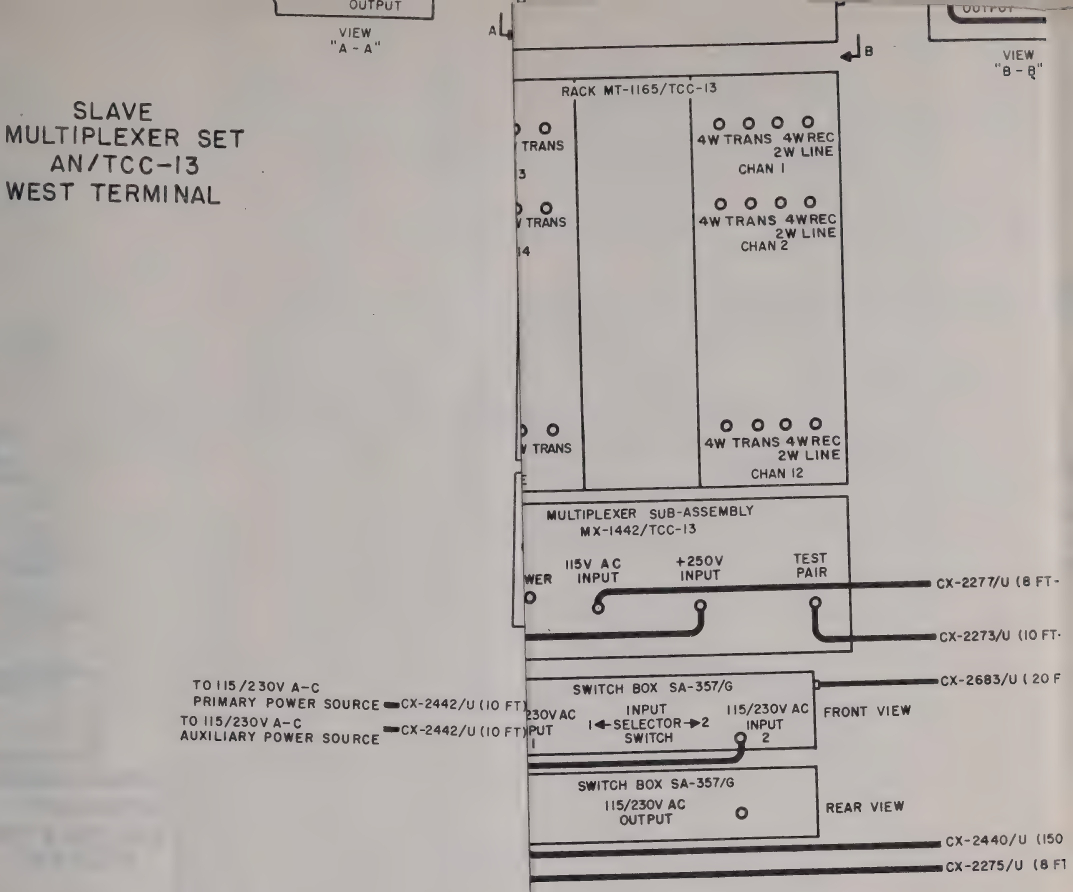

MASTER MULTIPLEXER SET AN/TCC-13 WEST TERMINAL
SLAVE MULTIPLEXER SET AN/TCC-13 WEST TERMINAL
MULTIPLEXER GROUP AN/TCA-1 (UNDER TEST)
MASTER MULTIPLEXER SET AN/TCC-13 EAST TERMINAL
SLAVE MULTIPLEXER SET AN/TCC-13 EAST TERMINAL
MULTIPLEXER TD-60/TCC-13
RACK MT-1165/TCC-13
MULTIPLEXER SUB-ASSEMBLY MX-1442/TCC-13
SWITCH BOX SA-357/G
OSCILLOSCOPE OS-25/G
AUDIO TEST SET TS-762/TC
CONTROL MONITOR C-1151/TC
ACCESSORIES CASE CY-1334/G
POWER SUPPLY PP-691/G
VOLTAGE REGULATOR CN-236/G
PULSE FORM RESTORER TD-68/G
RACK MT-1433/TCA-1
REMOTE KEYING
MULTIPLEXER SUB-ASSEMBLY MX-1442/TC
WESTGOING SCOPE SYNC
EASTGOING SCOPE SYNC
OUTPUT TO EASTFACING XMTR
OUTPUT TO WESTFACING XMTR
INPUT FROM EASTFACING REC
INPUT FROM WESTFACING REC
PARTY LINE CHANNEL 2
PARTY LINE CHANNEL 1
EASTFACING
WESTFACING
CHAN 1
CHAN 2
CHAN 8
CHAN 12
CHAN 13
CHAN 14
SPARE
4W REC
2W LINE
4W TRANS
MASTER OUTPUT TO RF
SLAVE OUTPUT
INPUT FROM SLAVE
46 CHAN SYNC
MTPX SYNC OUTPUT
SLAVE INPUT
OUTPUT TO SLAVE
DEMTPX SYNC OUTPUT
MASTER INPUT FROM RF
50-OHM PLUG NOT CONNECTED
VIEW "A-A"
VIEW "B-B"
MTPX SYNC INPUT
DEMTPX SYNC INPUT
EXTERNAL SYNC INPUT
115V AC INPUT
SIGNAL IN
SIGNAL OUT
TEST PAIR
+250V 115V AC INPUT
UTILITY POWER
AC POWER INPUT
115V AC OUTPUT
+250V OUTPUT
115V AC OUT
AC POWER OUTPUT
115/230V AC INPUT
INPUT 1 ◄ SELECTOR ► 2 SWITCH
115/230V AC OUTPUT
FRONT VIEW
REAR VIEW
TO GROUND ROD
TO 115/230V A-C PRIMARY POWER SOURCE
TO 115/230V A-C AUXILIARY POWER SOURCE
TO 115/230V A-C POWER SOURCE
AC POWER IN 115V AC
AC POWER OUT
AC POWER IN 230V AC
CG-1040A/U (15 FT-3 IN)
CG-1040A/U (25 FT-3 IN)
CG-409C/U (25 FT)
CX-2682/U (3 FT-3 IN)
CX-2272/U (3 FT-5 IN)
CX-2276/U (8 FT-4 IN)
CX-2441/U (8 FT-4 IN)
CX-2277/U (8 FT-4 IN)
CX-2273/U (10 FT-4 IN)
CX-2683/U (20 FT)
CX-2440/U (15 FT)
CX-2440/U (150 FT)
CX-2275/U (8 FT-4 IN)
CX-2442/U (10 FT)
TM5091-707

Figure 181. Test set-up, using Multiplexer Group AN/TCA-1 (45-channel operation).



SLAVE
MULTIPLEXER SET
AN/TCC-13
WEST TERMINAL

OUTPUT
VIEW "A - A"
A
B
OUTPUT
VIEW "B - B"
RACK MT-1165/TCC-13
TRANS
3
TRANS
14
TRANS
4W TRANS 4W REC 2W LINE CHAN 1
4W TRANS 4W REC 2W LINE CHAN 2
4W TRANS 4W REC 2W LINE CHAN 12
MULTIPLEXER SUB-ASSEMBLY MX-1442/TCC-13
WER
115V AC INPUT
+250V INPUT
TEST PAIR
CX-2277/U (8 FT-
CX-2273/U (10 FT-
CX-2683/U (20 F
SWITCH BOX SA-357/G
230V AC
PUT
1
INPUT
1 ◄ SELECTOR ► 2
SWITCH
115/230V AC INPUT 2
FRONT VIEW
TO 115/230V A-C PRIMARY POWER SOURCE
CX-2442/U (10 FT)
TO 115/230V A-C AUXILIARY POWER SOURCE
CX-2442/U (10 FT)
SWITCH BOX SA-357/G
115/230V AC OUTPUT
REAR VIEW
CX-2440/U (150
CX-2275/U (8 FT

Section III. TROUBLE SHOOTING THE MODEM

170. Modem Trouble-shooting Data

The following data may assist maintenance personnel when trouble shooting the modem:

Figure No.	Description
261	Modem, schematic diagram.
276	Modem, wiring diagram.
182	Modem, right side view.
183	Modem, left side view.
184	Modem test extension in position.
185	Modem, test extension with modem in position.
186	Modem, tube socket voltage and resistance diagram.

171. Modem Test Equipment Required

The following test equipment is required for trouble shooting and final testing the modem:

Item	Tecnical manual
a. Multiplexer Group AN/TCA–1.	
b. Audio Oscillator TS–382A/U.	TM 11–2684A
c. Decade Resistance Box TS–679/U.	TM 11–5520
d. Electronic Multimeter ME–6/U.	TM 11–5549B
e. Electronic Multimeter TS–505/U.	TM 11–5511
f. Field Telephone EE–8–B (Two).	TM 11–333
g. Signal Generator SG–15/PCM.	TM 11–2096

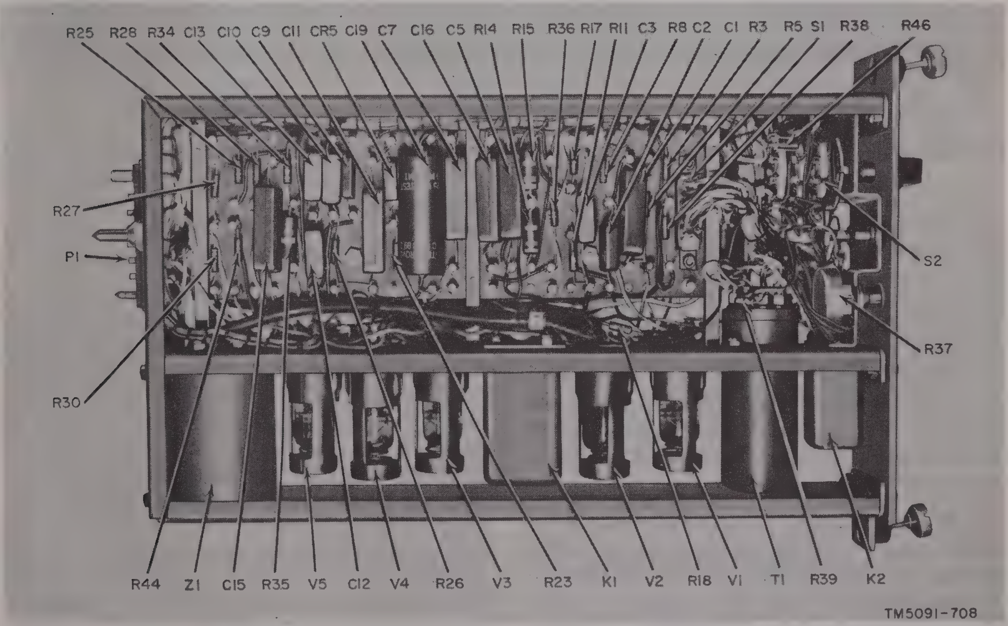

R25
R28
R34
C13
C10
C9
C11
CR5
C19
C7
C16
C5
R14
R15
R36
R17
R11
C3
R8
C2
C1
R3
R5
S1
R38
R46
R27
P1
R30
S2
R37
R44
Z1
C15
R35
V5
C12
V4
R26
V3
R23
K1
V2
R18
V1
T1
R39
K2
TM5091-708

Figure 182. Modem, right side view.

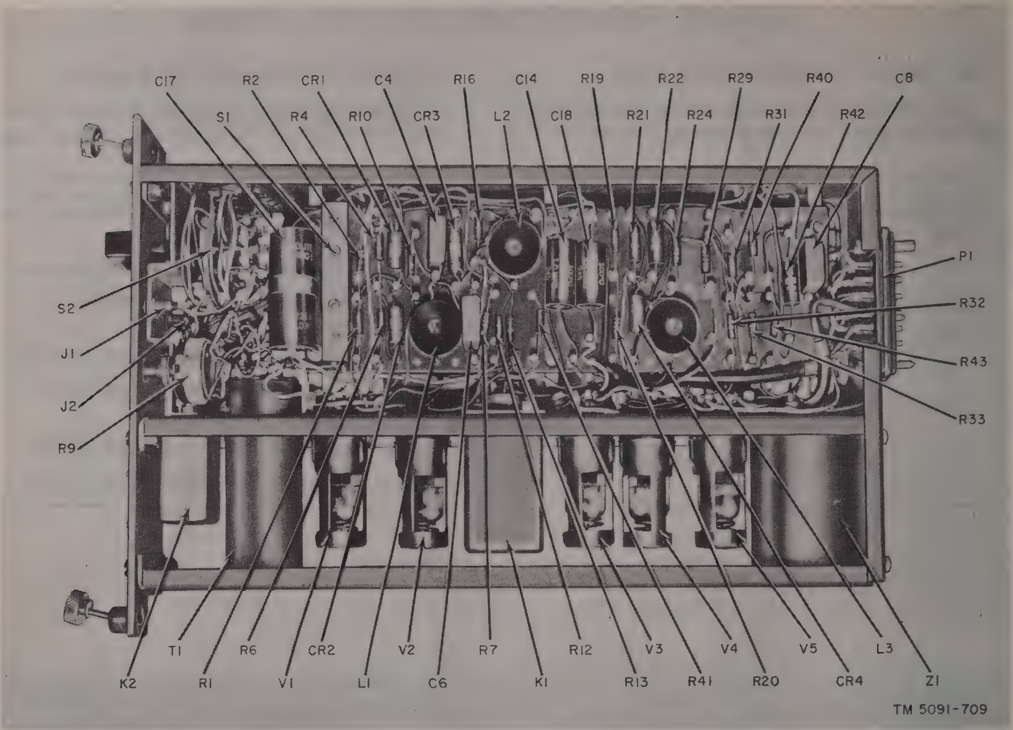


Figure 183. Modem, left side view.

172. Modem Trouble-shooting Procedure
(fig. 184 and 185)

a. The best means of trouble shooting this unit is by means of wave form comparison. Abnormal wave form indicates a fault between the point where the wave form is last normal and the point where it is observed to be abnormal. The wave form comparison procedures (ch 4) permit localization of the trouble to a particular stage. The wave form comparison procedures described in this paragraph may permit localization of the trouble to the particular defective part in the stage.

b. Trouble shooting in the modem should not be attempted while the set is carrying traffic. Trouble shooting on the defective unit should be done during a shut-down period or some other appropriate time. Electrical Connector Assembly J–535/G is supplied so that testing can be carried out while operating but not carrying traffic. The modem under test is removed, the assembly is inserted, and the modem then plugged into the assembly.

173. Modem Tube Socket Voltages and Resistances

Figure 186 shows the normal d-c voltages between the tube socket terminals and the chassis ground as measured by a vacuum-tube voltmeter. The values given are typical for normal 23-channel master operation and may vary by ±10 per cent. The B+ supply is 260 volts dc. Figure 186 also shows the normal resistance in ohms between the tube socket terminals and the chassis ground as calculated. For long drift capacitive circuits, sufficient time is allowed for the readings to be stabilized. The values given are for 23-channel operation with the particular modem on the test extension and the modem switches in normal (OPER) position. The values may vary by ±10 per cent.

174. Modem Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the modem.

Symptom	Probable trouble	Correction
1. Incorrect pulse at ppm test point J1.	1. Open L1. No sawtooth at pin 7 of V1. Open L2. CR3 shorted. Grounded J1.	1. Replace L1. Check waveforms (ch 4). Replace L2. Replace CR3. Replace J1.
2. No pulse-position modulation, but pulse present.	2. Open between terminals 1 and 2 or 9 and 11 of hybrid T1. Shorted CR1. Faulty S1.	2. Replace hybrid T1. Replace CR1. Replace S1.
3. 20-cps ringing input does not blank pulse out.	3. Faulty K1 relay. Faulty S1.	3. Replace K1. Replace S1.
4. No pwm at test point J2.	4. L3 open. CR4 shorted. No sawtooth at pin 2 of V3.	4. Replace L3. Replace CR4. Refer to chapter 4.
5. Incorrect pwm at test point J2.	5. CR4 faulty. CR5 faulty. L3 faulty. Faulty modem pulse train at pin 8 of V3.	5. Replace CR4. Replace CR5. Replace L3. Refer to chapter 4.
6. Pwm waveshape correct but low or no audio output.	6. Open filter Z1. Open R37. Defective hybrid T1. Defective S1.	6. Replace Z1. Replace R37. Replace T1. Replace S1.
7. No ringing output when incoming pulse drops.	7. Defective K2. Defective alarm circuit in common unit. Incorrect pwm. No 20-cps ringing current available from control monitor to pins N and P on P1.	7. Replace K2. Refer to chapter 4. Refer to chapter 4. Refer to chapter 4.

175. Modem Modulator Tests

The following tests should be used as a reference and as a test procedure after major repairs:

Note. For the four-wire test, one AN/TCC–13 can be used; for the two-wire test, two AN/TCC–13's must be used back to back to prevent singing. It is assumed that the terminals are operating properly and that the channel pulses are aligned. (All 23 channels are not needed.) A modem to be tested should be removed from the modem rack in Multiplexer Group AN/TCA–1 and inserted in the modem rack in Multiplexer Set AN/TCC–13. The pulse then should be properly aligned in the pulse train (this can be checked at the PULSE TRAIN OUTPUT test point on Multiplexer Set AN/TCC–13 panel). For the four-wire test, the modem 2W-4W switch (fig. 41) must be in the 4W position; for the two-wire test, the modem 2W-4W switch must be in the 2W position.

a. Four-wire Operation.

(1) *Wave forms.* With the pulse properly positioned in the pulse train, the following wave forms should be measured, and they should not vary by more than 25 per cent in width and amplitude from those in the referenced figures:

(*a*) Ppm test point, figure 88.

(*b*) Pwm test point, figure 92.

(2) *PULSE POSITION control.*

(*a*) Vary the modem PULSE POSITION control (fig. 48) from maximum to minimum. The pulse should move at least 3.5 microseconds.

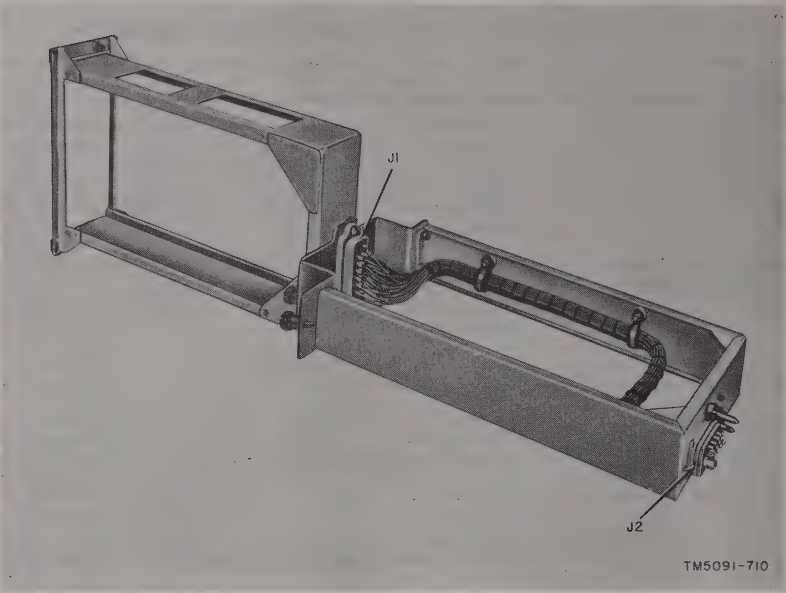

J1
J2
TM5091-710

Figure 184. Modem test extension in position.

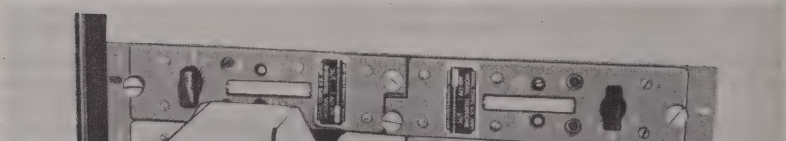


Figure 185. Modem test extension with modem in position.

(*b*) Reposition the pulse properly in the pulse train.

(3) *Modulation.* Modulate the channel pulse to ±.5 microsecond with a 1,000-cycle tone from Audio Test Set TS-762/TC. The input level for ±.5 microsecond should be —4 dbm ±1 dbm.

(4) *Output level and OUTPUT AUDIO GAIN control.*

(*a*) With the pulse modulated ±.5 microsecond, vary the modem OUTPUT AUDIO GAIN control from maximum to minimum. The output should vary from —6 dbm or less to +4 dbm or greater.

(*b*) Reset the gain control for +1 dbm output.

(5) *Distortion.*

(*a*) With the output level set for 0 dbm at full modulation (±.5 microsecond), insert a —10-dbm signal into the modulator as follows:

1. Connect the SEND OUT front panel jacks on the audio test set to the 4W TRANS binding posts of the particular modem being tested.

2. Set the audio test set SEND DBM knob for —10.

(*b*) Measure the demodulator output distortion on the audio test set as follows:

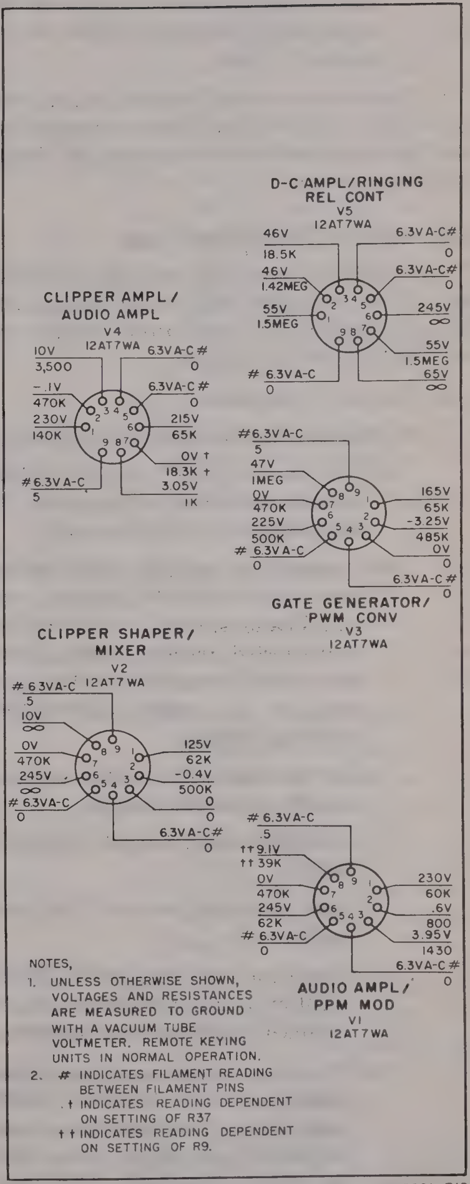
1. Push the control monitor REC push button.

2. Turn the selector switch on the particular modem being tested to the RR position.

3. Push the audio test set DIST AT 1000~ button.

4. Rotate the audio test set RECEIVE DBM knob until a readable value is obtained on the audio test set meter.

5. The distortion is the sum of the meter reading and the RECEIVE DBM knob setting. The distortion should not be greater than —33 dbm.


D-C AMPL/RINGING REL CONT
V5
12AT7WA
46V
18.5K
46V
1.42MEG
55V
1.5MEG
# 6.3V A-C
0
6.3V A-C#
0
6.3V A-C#
0
245V
∞
55V
1.5MEG
65V
∞
CLIPPER AMPL/ AUDIO AMPL
V4
12AT7WA
10V
3,500
-.1V
470K
230V
140K
#6.3V A-C
5
6.3V A-C #
0
6.3V A-C #
0
215V
65K
0V †
18.3K †
3.05V
1K
#6.3V A-C
5
47V
1MEG
0V
470K
225V
500K
# 6.3V A-C
0
165V
65K
-3.25V
485K
0V
0
6.3V A-C #
0
GATE GENERATOR/ PWM CONV
V3
12AT7WA
CLIPPER SHAPER/ MIXER
V2
12AT7 WA
# 6.3V A-C
.5
10V
∞
0V
470K
245V
∞
# 6.3V A-C
0
125V
62K
-0.4V
500K
0
0
6.3V A-C#
0
# 6.3V A-C
.5
†† 9.1V
†† 39K
0V
470K
245V
62K
# 6.3V A-C
0
230V
60K
.6V
800
3.95V
1430
6.3V A-C #
0
AUDIO AMPL/ PPM MOD
V1
12AT7WA
NOTES,
1. UNLESS OTHERWISE SHOWN, VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A VACUUM TUBE VOLTMETER. REMOTE KEYING UNITS IN NORMAL OPERATION.
2. # INDICATES FILAMENT READING BETWEEN FILAMENT PINS
† INDICATES READING DEPENDENT ON SETTING OF R37
†† INDICATES READING DEPENDENT ON SETTING OF R9.

TM5091-712

Figure 186. Modem tube socket voltage and resistance diagram.

(*c*) Reset the demodulator output to 0 dbm with full modulation.

(6) *Signal-to-noise ratio.* Remove the modulation and measure the noise at the demodulator output. It should not exceed —65 dbm.

b. Two-wire Operation. Modulate the channel pulse with a 1,000-cps tone from the audio test set. The input level for ±.5 microsecond should be 0 dbm ±1 dbm.

176. Modem Demodulator Tests

The following tests are used for reference and as test procedures after major repairs. Refer to paragraph 172 for the procedures on two-wire and four-wire operation.

a. Four-wire Operation.

(1) *Limiting characteristics (spot check).*

(*a*) Set the OUTPUT AUDIO GAIN control for 0 dbm output with full modulation (±.5 microsecond).

(*b*) Connect the external audio oscillator to the 4W TRANS binding posts (modulator section) of the modem being tested. Insert a 1,000-cps signal at the levels given below, and measure the modem demodulator output as follows:

1. Set the particular modem selector switch to the RR position.

2. Push the control monitor REC push button.

3. Push the audio test set F1A push button.

4. Rotate the audio test set RECEIVE DBM knob until a readable value is obtained on the audio test set meter.

5. The output is the sum of the meter reading and the RECEIVE DBM knob setting. The demodulator output should not vary by more than the values given below. The limiting level normally is that which produced ±.5 usec pulse duration.

Modulator input	Demodulator output
+4 dbm, .49 v rms	0 ±2.5 dbm
+6 dbm, 1.55 v rms	—6 ±2.5 dbm
+16 dbm, 4.9 v rms	—8 ±2.5 dbm

(*c*) For a three-point curve instead of a two-point curve, repeat the procedure given in subparagraph (*b*) above, including the additional point of —24-dbm modulator input giving a +9 ±4.0-dbm demodulator output.

(2) *Frequency characteristics (spot check).*

(*a*) Connect the external audio oscillator to the particular modem 4W TRANS binding posts.

(*b*) Set the external audio oscillator for –4 dbm at 1,000 cps, and the modem OUTPUT AUDIO GAIN control for 0 dbm.

(*c*) Measure the demodulator output at 300 cps and 3,500 cps with a constant signal level of +4 dbm into the modulator (subpar. (1)(*b*) above). The demodulator output reading should be +2 dbm at both frequencies. The modulator input should be taken from the external audio oscillator and the demodulator output should be measured on the audio test set.

(*d*) For a six-point curve instead of a three-point curve, repeat the procedure given in subparagraph (*c*) above, including the additional frequencies of 600, 2,000, and 3,000 cps.

(3) *Input and output impedances.* The two-wire and four-wire input and output impedances should be 600 ohms +10 per cent at 1,000 cps.

(*a*) *Input impedance, 4W.* To find the input and output impedance, use Audio Oscillator TS–382A/U, Electronic Multimeter TS–505/U, and Decade Resistance Box TS–679/U and follow the procedure below:

1. Connect the decade resistance box in series between one output terminal of the audio oscillator and terminal T on plug P1 of the modem under test.

2. Connect the other audio oscillator terminal directly to terminal W of plug P1 of the modem under test.

3. Set the decade resistance box at 600 ohms and the audio oscillator at 1 kilocycle with an output of .25 volt rms.

4. With the vtvm, read the voltage across terminals T and W of the modem under test and the voltage at the terminals of the decade resistance box. If both voltage readings are the same, the impedance at modem terminals T and W is 600 ohms.

5. If the voltage readings across the modem terminals and the decade resistance box are not the same, change the resistance value of the decade resistance box until identical voltages are read. The resistance reading of the decade resistance box will then indicate the impedance value at the modem terminals.

(*b*) *Output impedance, 4W.* To measure the output impedance for four-wire operation of the modem, follow the procedure described in subparagraph (*a*) above, substituting terminals U and X for terminals T and W on plug P1.

(*c*) *Input and output impedances, 2W.* To measure the input and output impedances for two-wire operation of the modem, follow the procedure described in subparagraph (*a*) above, substituting terminals U and X for T and W.

(4) *Modem panel switch operation.*

(*a*) The modem panel switch operations are as follows:

OPER – Normal operating position.
SL – Disconnects the telephone line from the demodulator and connects the four-wire REC telephone wires to the test pair.
RL – Disconnects the telephone line from the modulator and connects the four-wire TRANS telephone wires to the test pair.
SR – Disconnects the four-wire TRANS telephone line from the modulator and connects the modulator to the test pair.
RR – Disconnects the four-wire REC telephone line from the demodulator to the test pair.

(*b*) The modem panel switch operation can be tested as follows:

1. Monitor the demodulator output (four-wire REC terminal) on the test set. Place the control monitor switch in the SEND position and the test set SEND DBM at –4 dbm.

(a) With the modem switch in the SR position, the channel pulse should be modulated and the meter on the audio test set should indicate 0 dbm. (It is assumed that the OUTPUT AUDIO GAIN control is still set for 0-dbm output with –4-dbm input.)

(b) With the modem switch in the SL position, the channel should no longer be modulated and the audio test set meter should indicate –4 dbm.

2. Connect the audio test set SEND OUT terminals to the modulator input (four-wire TRANS terminals). Place the control monitor switch in the REC position.

(a) With the modem switch in the RR position, the pulse should be modulated and the valve on the test set meter should indicate 0 dbm.

(b) With the modem switch in the RL position, the pulse should not be modulated and the audio test set meter should indicate –4 dbm.

(5) *Ringing circuits.* Inject a 20-cps, 100-volt signal into the modulator (with field Telephone EE–8–B or by placing the control monitor switch in the SEND position, the modem switch in the SR position, and pressing the RING switch on the control monitor). The channel pulse should be blanked out and the demodulator output should have ringing voltage across it (20 cps, 100 volts). An EE–8–B connected across the demodulator output (four-wire REC) should ring.

(6) *Terminal balance to ground (input and output).* Test the terminal balance to ground as shown in figure 187. The resistors should be 600 ohms ±5 per cent. The ratio $\frac{V}{E}$ should be less than .01.

Note. Be sure that the bridge (fig. 187) is properly balanced. When constructing the bridge, select resistors to give a zero reading on meter V with the bridge connected to the equipment but the ground connection, from junction R1 and R3, open. Reconnecting the ground connection would produce a voltage reading (V) depending on the unbalance.

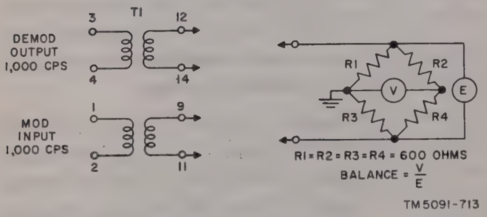


Figure 187. Terminal balance to ground test set-up.

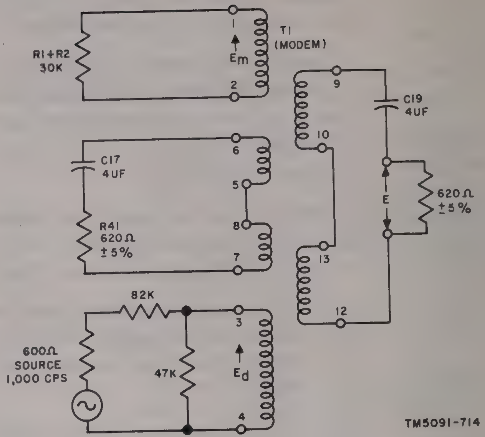


Figure 188. Transhybrid test set-up.

(7) *Output level.* Use a test AN/TCC–13 with its corresponding channel being modulated ±.5 microsecond and monitor the demodulator output on the test channel. Vary the OUTPUT AUDIO GAIN control from maximum to minimum. The output should vary from +6 dbm or less to +4 dbm or greater.

b. Two-wire Operation.

(1) *Input impedance.* Refer to subparagraph *a*(3) above.

(2) *Modem panel switch operation.* Monitor the two-wire line terminals on the test set. Place the control monitor switch in the SEND position, and the test set SEND at –4 dbm. (Be sure that the corresponding channel is not being modulated in the other terminal.)

(*a*) With the modem switch in SR or RR, modulate the pulse. The test set should not read.

(*b*) With the modem switch in SL or RL, do not modulate the pulse, and the test set should read +4 dbm.

(3) *Transhybrid loss.* Use the accompanying test circuit (fig. 188) and adjust the input source for E to be 0 dbm (.775v). Ed will equal approximately 8.5 volts. Measure Em/Ed, the transhybrid loss. It should be at least 40 db. The hybrid transformer is tested in the modem. Leads to terminals 1 and 2 of T1 must be opened and the test circuit inserted as shown in figure 188. Similarly, the lead between C19 and terminal 12 of T1 must be opened and the 620-ohm resistor inserted.

Section IV. TROUBLE SHOOTING THE DELAY LINE

177. Delay Line Trouble-shooting Data

The following data may assist maintenance personnel in trouble shooting the delay line.

Figure No.	Description
Figure 263	Delay line, schematic diagram.
Figure 278	Delay line, wiring diagram.
Figure 189	Delay line, location of parts.

178. Test Equipment Required for Delay Line

Oscilloscope OS–25/G is the only test equipment required to trouble shoot the delay line.

179. Delay Line Test Procedure

Repairs on the delay line should not be attempted except in the most unusual circumstances. Assuming it is absolutely necessary to repair the line, follow the test procedures below.

Note. In the following continuity checks, all D&I-THRU plugs and PARTY LINE-PRIV plugs are removed.

a. Initial Connections. The delay line consists of four 40-usec delay lines, the inputs of which are J1, J2, J3, and J4. DEMTPX GATE OUTPUT jack J8 of the video restorer should be connected to either J1, J2, J3, or J4, depending on which line is being tested. All lines must be tested separately. Refer to the delay line wiring diagram (fig. 278) for the arrangement of all sections.

b. Reflections. The negative gate input from J8 to the delay line should be observed on a scope which is synchronized from SCOPE SYNC jack J10. There should be no negative reflections at the input greater than 10 per cent and no positive reflection greater than 20 per cent. A check should be made at each tap to see that there are no double pulses.

c. Time Delay. With the oscilloscope still being synchronized from J10, observe the delay line output (across 3,000-ohm terminating resistor R3, R5, R9, or R11). The time delay from input pulse to output pulse across the terminating resistor should be 41 usec minimum and 45 usec maximum, measured between the 50 per cent amplitude points of the leading edge.

Note. Timing pips 5.2 usec apart can be obtained from Oscilloscope OS–25/G for measurement purposes.

d. Attenuation. The output pulse should be at least 85 per cent in amplitude of the input pulse.

180. Delay Line Trouble-shooting Chart

The following chart will assist maintenance personnel in trouble-shooting the delay line.

Symptom	Probable trouble	Correction
1. Bad reflections.	*a.* Open or shorted coil; resistance between taps of coils (approx 40 ohms). *b.* Open coil or shorted capacitor; check resistance to ground from coil junctions (should be greater than 4,000 ohms).	*a.* Replace delay line sections. *b.* Replace delay line sections.
2. No sawtooth.	Check lead to modem for short. Modem modulator is pin C, modem demodulator is pin E of modem receptacle on mounting rack or of modem plug P1.	Replace delay line sections.

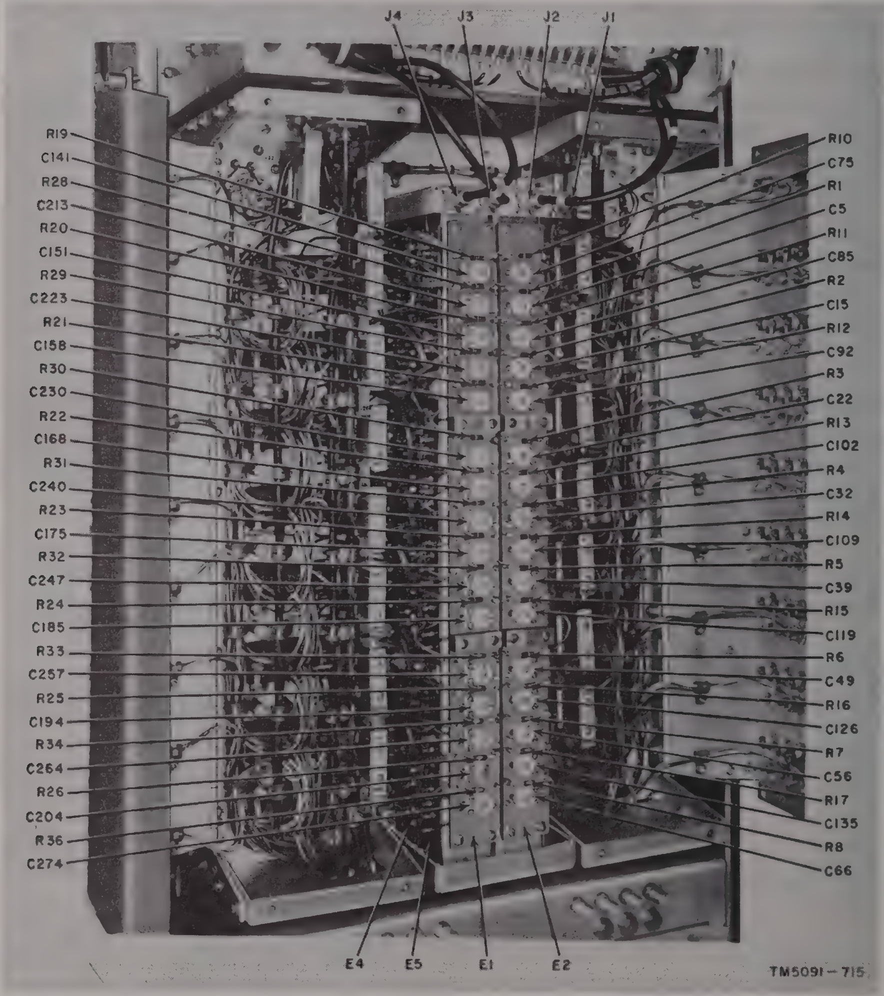

J4
J3
J2
J1
R19
C141
R28
C213
R20
C151
R29
C223
R21
C158
R30
C230
R22
C168
R31
C240
R23
C175
R32
C247
R24
C185
R33
C257
R25
C194
R34
C264
R26
C204
R36
C274
R10
C75
R1
C5
R11
C85
R2
C15
R12
C92
R3
C22
R13
C102
R4
C32
R14
C109
R5
C39
R15
C119
R6
C49
R16
C126
R7
C56
R17
C135
R8
C66
E4
E5
E1
E2
TM5091-715

Figure 189. Delay line, location of parts.

Section V. TROUBLE SHOOTING THE MOUNTING RACK

181. Mounting Rack Trouble-shooting Data

The following data will assist maintenance personnel in trouble shooting the mounting rack:

Figure No.	Description
262	Mounting rack, schematic diagram.
277	Mounting rack, wiring diagram.
190	Mounting rack, front view.
191	Mounting rack, rear view, door open.
192	A-c power distribution diagram.

182. Test Procedure and Test Equipment Required for Mounting Rack

a. Test Equipment. The only test equipment required for trouble shooting the mounting rack is Multiplexer TS–352B/U. Refer to TM 11–5527A for operation techniques of the multimeter.

b. Test Procedure. The only test to be made for trouble shooting the mounting rack is that for continuity. Make the following circuit continuity checks:

c. Filament Circuit.

(1) Check for a short circuit between the following points:
- (*a*) E149 and pin F of J15, J19, J23, J27, J31, J35, J39 and J43.
- (*b*) E146 and pin F of J16, J20, J24, J28, J32, J36, J40 and J44.
- (*c*) E147, E148, and chassis ground.
- (*d*) E148 and pin S of J15, J19, J23, J27, J31, J35, J39 and J43.
- (*e*) E147 and pin S of J16, J20, J24, J28, J32, J36, J40 and J44.

(2) Check for an open circuit between E148 and E149 and E146 and E147.

d. B+ Circuit.

(1) Check for a short circuit between the following points:
- (*a*) J15D, J19D, J23D, J23H, J27D and J27H.
- (*b*) J31D, J31H, J35D, J35H, J39D, J39H, J43D and J43H.
- (*c*) J16D, J20D, J24D, J24H, J28D and J28H.
- (*d*) J32D, J32H, J36D, J36H, J40D, J40H, J44D and J44H.

(2) Check for open circuit between the four B+ groups. If continuity within the above groups exists, then check for an open circuit between J15D, J31D, J16D, J32D, and an open circuit from ground to J15D, J31D, J16D, J32D.

e. 2W-4W Circuits.

(1) *4W TRANS.* Check for continuity between the applicable modem channel 4W TRANS pair and pins T and W for J15, J16, J19, J20, J23, J24, J27, J28, J31, J32, J35, J36, J39, J40, J43 and J44.

(2) *4W REC-2W LINE.* Check for continuity between the applicable modem channel 4W REC-2W LINE pair and pins U and X for J15, J16, J19, J20, J23, J24, J27, J28, J31, J32, J35, J36, J39, J40, J43, and J44.

f. PARTY LINE-PRIV Circuit. Check for continuity between the following points:

Pin A of J11 to pin U of J16.
Pin B of J11 to pin 4 of T1.
Pin C of J11 to pin W of J15.
Pin E of J11 to pin X of J16.
Pin H of J11 to C276.
Pin J of J11 to pin T of J15.
Pin L of J11 to pin T of J16.
Pin P of J11 to pin W of J15.
Pin S of J11 to pin 2 of T1.
Pin T of J11 to pin W of J16.
Pin V of J11 to pin U of J15.
Pin U of J11 to C277.
Pin A of J12 to pin U of J20.
Pin B of J12 to pin 4 of T2.
Pin C of J12 to pin W of J19.
Pin E of J12 to pin X of J20.
Pin H of J12 to C282.
Pin J of J12 to pin T of J15.

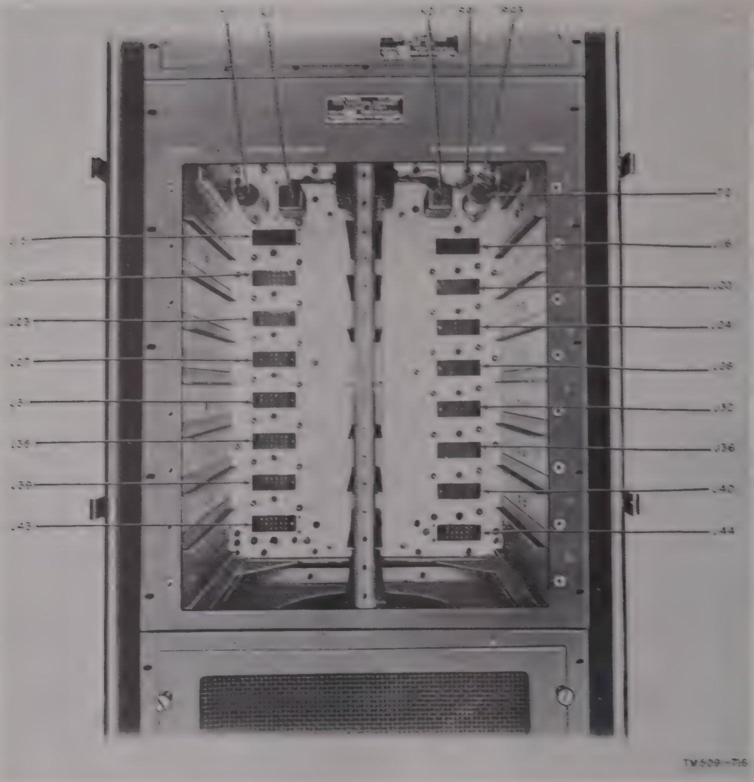


Figure 190. Mounting rack, front view.

Pin L of J12 to pin T of J16.
Pin P of J12 to pin W of J15.
Pin S of J12 to pin 2 of T2.
Pin T of J12 to pin W of J16.
Pin V of J12 to pin U of J15.
Pin U of J12 to C283.

g. D&I-THRU Circuits.

(1) Check for continuity between the following points:

Pin A of J13 to chassis ground.
Pin F of J13 to E4-3 of delay line.
Pin L of J13 to chassis ground.
Pin M of J13 to pin C of J16.
Pin P of J13 to J5.
Pin R of J13 to E2-4 of delay line.
Pin A of J14 to chassis ground.
Pin F of J14 to E5-3 of delay line.
Pin L of J14 to chassis ground.
Pin M of J14 to pin C of J15.
Pin P of J14 to J10.
Pin R of J14 to E1-3 of delay line.
Pin A of J17 to chassis ground.
Pin F of J17 to E4-8 of delay line.
Pin L of J17 to chassis ground.
Pin M of J17 to pin C of J20.
Pin P of J17 to J5.
Pin R of J17 to E2-8 of delay line.
Pin A of J18 to chassis ground.
Pin F of J18 to E5-8 of delay line.
Pin L of J18 to chassis ground.
Pin M of J18 to pin C of J19.
Pin P of J18 to J10.
Pin R of J18 to E1-7 of delay line.
Pin A of J21 to chassis ground.
Pin F of J21 to E4-13 of delay line.
Pin L of J21 to chassis ground.

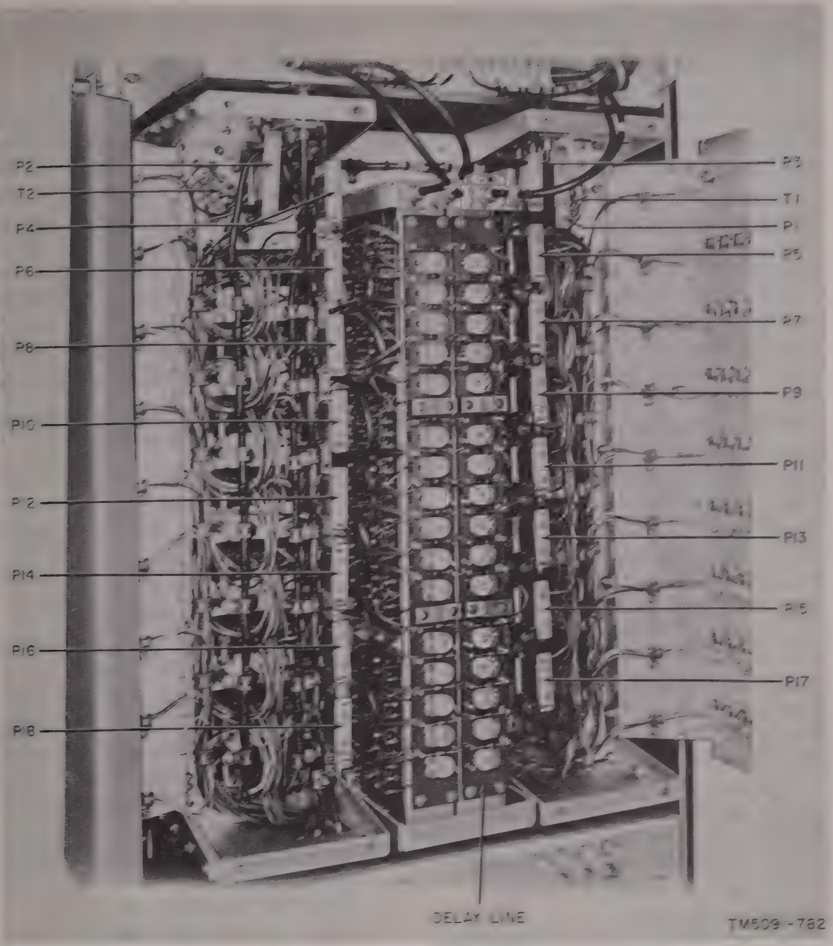


Figure 191. Mounting rack, rear view, door open.

Pin M of J21 to pin C of J24.
Pin P of J21 to J5.
Pin R of J21 to E2-12 of delay line.
Pin A of J22 to chassis ground.
Pin F of J22 to E5-13 of delay line.
Pin L of J22 to chassis ground.
Pin M of J22 to pin C of J23.
Pin P of J22 to J10.
Pin R of J22 to E1-11 of delay line.
Pin A of J25 to chassis ground.
Pin F of J25 to E4-18 of delay line.
Pin L of J25 to chassis ground.
Pin M of J25 to pin C of J28.
Pin P of J25 to J5.
Pin R of J25 to E2-16 of delay line.
Pin A of J26 to chassis ground.
Pin F of J26 to E5-18 of delay line.
Pin L of J26 to chassis ground.
Pin M of J26 to pin C of J27.
Pin P of J26 to J10.
Pin R of J26 to E1-15 of delay line.
Pin A of J29 to chassis ground.
Pin F of J29 to E4-23 of delay line.
Pin L of J29 to chassis ground.
Pin M of J29 to pin C of J32.
Pin P of J29 to J5.

Pin R of J29 to E2-20 of delay line.
Pin A of J30 to chassis ground.
Pin F of J30 to E5-23 of delay line.
Pin L of J30 to chassis ground.
Pin M of J30 to pin C of J31.
Pin P of J30 to J10.
Pin R of J30 to E1-19 of delay line.
Pin A of J33 to chassis ground.
Pin F of J33 to E4-28 of delay line.
Pin L of J33 to chassis ground.
Pin M of J33 to pin C of J36.
Pin P of J33 to J5.
Pin R of J33 to E2-24 of delay line.
Pin A of J34 to chassis ground.
Pin F of J34 to E5-28 of delay line.
Pin L of J34 to chassis ground.
Pin M of J34 to pin C of J35.
Pin P of J34 to J10.
Pin R of J34 to E1-23 of delay line.
Pin A of J37 to chassis ground.
Pin F of J37 to E4-33 of delay line.
Pin L of J37 to chassis ground.
Pin M of J37 to pin C of J40.
Pin P of J37 to J5.
Pin R of J37 to E2-28 of delay line.
Pin A of J38 to chassis ground.
Pin F of J38 to E5–33 of delay line.
Pin L of J38 to chassis ground.
Pin M of J38 to pin C of J39.
Pin P of J38 to J10.
Pin R of J38 to E1-27 of delay line.
Pin A of J41 to chassis ground.
Pin F of J41 to E4-38 of delay line.
Pin L of J41 to chassis ground.
Pin M of J41 to pin C of J44.
Pin P of J41 to J5.
Pin R of J41 to E2-26 of delay line.
Pin A of J42 to chassis ground.
Pin F of J42 to E5-38 of delay line.
Pin L of J42 to chassis ground.
Pin M of J42 to pin C of J43.
Pin P of J42 to J10.
Pin R of J42 to E1-31 of delay line.

(2) Check for continuity between the following points:

Pin E of J15 to E2-2 of delay line.
Pin E of J16 to E1-1 of delay line.
Pin E of J19 to E2-6 of delay line.
Pin E of J20 to E1-5 of delay line.
Pin E of J23 to E2-10 of delay line.
Pin E of J24 to E1-9 of delay line.
Pin E of J27 to E2-14 of delay line.
Pin E of J28 to E1–13 of delay line.
Pin E of J31 to E2-18 of delay line.
Pin E of J32 to E1-17 of delay line.
Pin E of J35 to E2-22 of delay line.
Pin E of J36 to E1-21 of delay line.
Pin E of J39 to E2-26 of delay line.
Pin E of J40 to E1-25 of delay line.
Pin E of J43 to E2-30 of delay line.
Pin E of J44 to E1-29 of delay line.

h. Miscellaneous. Check for continuity between the following points:

(1) J6 and pin V of J15, J19, J23, J27, J31, J35, J39, J43.
(2) J9 and pin V of J16, J20, J24, J28, J32, J36, J40, J44.
(3) J7 and pin K of J15, J19, J23, J27, J31, J35, J39, J43.
(4) J8 and pin K of J16, J20, J24, J28, J32, J36, J40, J44.
(5) Pin P of J23, J27, J31, J35, J39, J43.
(6) Pin P of J24, J28, J32, J36, J40, J44.
(7) Pin N of J23, J27, J31, J35, J39, J43.
(8) Pin N of J24, J28, J32, J36, J40, J44.
(9) Pin R of J15, J19, J23, J27, J31, J35, J39, J43.
(10) Pin R of J16, J20, J24, J28, J32, J36, J40, J44.
(11) Pin J of J23, J27.
(12) Pin J of J24, J28.
(13) Pin J of J31, J35, J39, J43.
(14) Pin J of J32, J36, J40, J44.
(15) Pin M of J15, J19, J23, J27, J31, J35, J39, J43.
(16) Pin M of J16, J20, J24, J28, J32, J36, J39, J44.
(17) Pin L of J15, J19, J23, J27, J31, J35, J39, J43.
(18) Pin L of J16, J20, J24, J28, J32, J36, J40, J44.

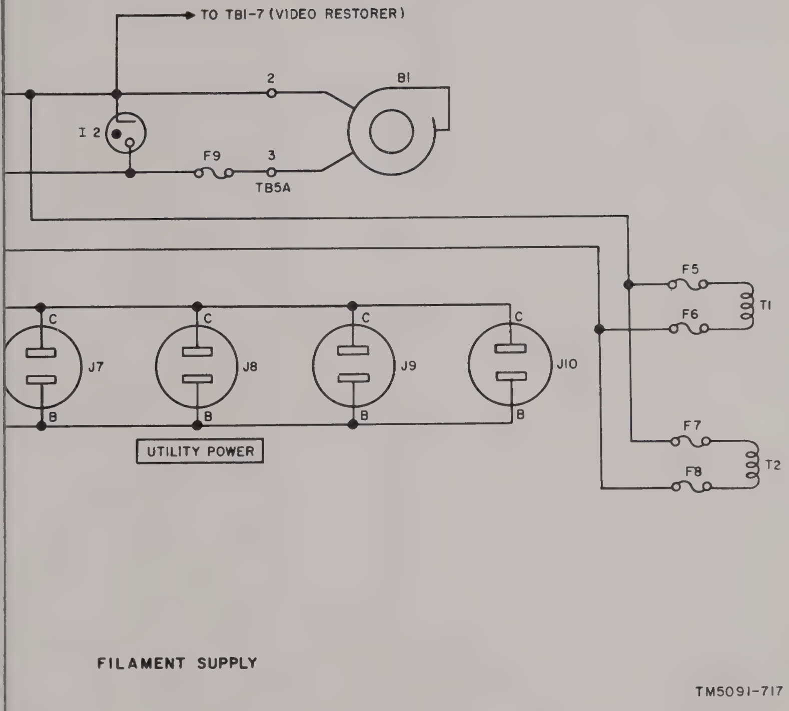

TO TBI-7 (VIDEO RESTORER)
2
BI
I 2
F9
3
TB5A
F5
TI
F6
C
C
C
C
J7
J8
J9
J10
B
B
B
B
UTILITY POWER
F7
T2
F8
FILAMENT SUPPLY
TM5091-717

Figure 192. A-c power distribution diagram.

Pin R of J29 to E2-20 of delay line.
Pin A of J30 to chassis ground.
Pin F of J30 to E5-23 of delay line.
Pin L of J30 to chassis ground.
Pin M of J30 to pin C of J31.
Pin P of J30 to J10.
Pin R of J30 to E1-19 of delay line.
Pin A of J33 to chassis ground.
Pin F of J33 to E4-28 of delay line.
Pin L of J33 to chassis ground.
Pin M of J33 to pin C of J36.
Pin P of J33 to J5.
Pin R of J33 to E2-24 of delay line.
Pin A of J34 to chassis ground.
Pin F of J34 to E5-28 of delay line.
Pin L of J34 to chassis ground.
Pin M of J34 to pin C of J35.
Pin P of J34 to J10.
Pin R of J34 to E1-23 of delay line.
Pin A of J37 to chassis ground.
Pin F of J37 to E4-33 of delay line.
Pin L of J37 to chassis ground.
Pin M of J37 to pin C of J40.
Pin P of J37 to J5.
Pin R of J37 to E2-28 of delay line.
Pin A of J38 to chassis ground.
Pin F of J38 to E5–33 of delay line.
Pin L of J38 to chassis ground.
Pin M of J38 to pin C of J39.
Pin P of J38 to J10.
Pin R of J38 to E1-27 of delay line.
Pin A of J41 to chassis ground.
Pin F of J41 to E4-38 of delay line.
Pin L of J41 to chassis ground.
Pin M of J41 to pin C of J44.
Pin P of J41 to J5.
Pin R of J41 to E2-26 of delay line.
Pin A of J42 to chassis ground.
Pin F of J42 to E5-38 of delay line.
Pin L of J42 to chassis ground.
Pin M of J42 to pin C of J43.
Pin P of J42 to J10.
Pin R of J42 to E1-31 of delay line.

(2) Check for continuity between the following points:

Pin E of J15 to E2-2 of delay line.
Pin E of J16 to E1-1 of delay line.
Pin E of J19 to E2-6 of delay line.
Pin E of J20 to E1-5 of delay line.
Pin E of J23 to E2-10 of delay line.
Pin E of J24 to E1-9 of delay line.
Pin E of J27 to E2-14 of delay line.
Pin E of J28 to E1–13 of delay line.
Pin E of J31 to E2-18 of delay line.
Pin E of J32 to E1-17 of delay line.
Pin E of J35 to E2-22 of delay line.
Pin E of J36 to E1-21 of delay line.
Pin E of J39 to E2-26 of delay line.
Pin E of J40 to E1-25 of delay line.
Pin E of J43 to E2-30 of delay line.
Pin E of J44 to E1-29 of delay line.

h. Miscellaneous. Check for continuity between the following points:

(1) J6 and pin V of J15, J19, J23, J27, J31, J35, J39, J43.
(2) J9 and pin V of J16, J20, J24, J28, J32, J36, J40, J44.
(3) J7 and pin K of J15, J19, J23, J27, J31, J35, J39, J43.
(4) J8 and pin K of J16, J20, J24, J28, J32, J36, J40, J44.
(5) Pin P of J23, J27, J31, J35, J39, J43.
(6) Pin P of J24, J28, J32, J36, J40, J44.
(7) Pin N of J23, J27, J31, J35, J39, J43.
(8) Pin N of J24, J28, J32, J36, J40, J44.
(9) Pin R of J15, J19, J23, J27, J31, J35, J39, J43.
(10) Pin R of J16, J20, J24, J28, J32, J36, J40, J44.
(11) Pin J of J23, J27.
(12) Pin J of J24, J28.
(13) Pin J of J31, J35, J39, J43.
(14) Pin J of J32, J36, J40, J44.
(15) Pin M of J15, J19, J23, J27, J31, J35, J39, J43.
(16) Pin M of J16, J20, J24, J28, J32, J36, J39, J44.
(17) Pin L of J15, J19, J23, J27, J31, J35, J39, J43.
(18) Pin L of J16, J20, J24, J28, J32, J36, J40, J44.

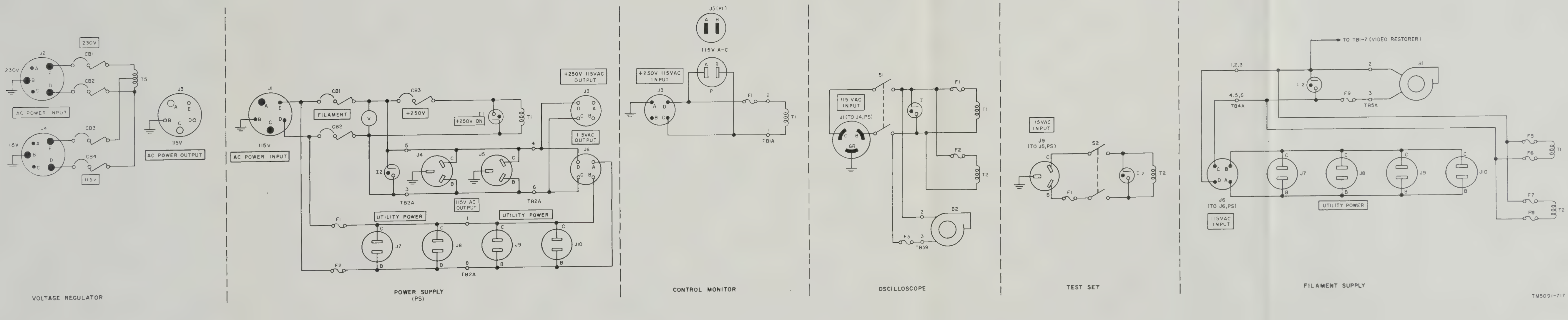

230V
J2
CB1
230V
CB2
T5
AC POWER INPUT
J4
115V
CB3
CB4
115V
J3
115V
AC POWER OUTPUT
VOLTAGE REGULATOR
J1
115V
AC POWER INPUT
CB1
FILAMENT
CB2
V
CB3
+250V
I1
+250V ON
T1
+250V 115VAC OUTPUT
J3
115VAC OUTPUT
J6
I2
J4
J5
5
4
3
6
TB2A
TB2A
115V AC OUTPUT
F1
UTILITY POWER
UTILITY POWER
1
J7
J8
J9
J10
F2
8
TB2A
POWER SUPPLY
(PS)
J5(P1)
115V A-C
P1
+250V 115VAC INPUT
J3
F1
2
1
TB1A
T1
CONTROL MONITOR
S1
115 VAC INPUT
J1(TO J4,PS)
GR
I
F1
T1
F2
T2
2
B2
F3
3
TB39
OSCILLOSCOPE
115VAC INPUT
J9
(TO J5,PS)
S2
F1
I2
T2
TEST SET
TO TB1-7 (VIDEO RESTORER)
1,2,3
2
B1
I2
4,5,6
TB4A
F9
3
TB5A
F5
F6
T1
F7
F8
T2
J6
(TO J6,PS)
115VAC INPUT
J7
J8
J9
J10
UTILITY POWER
FILAMENT SUPPLY
TM5091-717

Figure 192. A-c power distribution diagram.

Section VI. TROUBLE-SHOOTING MULTIPLEXER SUBASSEMBLY MX–1442/TC

183. Filament Supply Trouble-shooting Data

The following references will assist maintenance personnel in trouble shooting the filament supply.

Fig. No.	Description
264	Multiplexer Subassembly MX–1442/TC, over-all schematic diagram.
279	Multiplexer Subassembly MX–1442/TC, wiring diagram.
193	Filament supply, air filter removed, interior view.
194	Filament supply, back view, rear panel and remote keying units removed.
195	Filament supply, bottom view.
196	Remote keying unit.

184. Test Equipment Required for Filament Supply

The following test equipment is required for trouble shooting the power supply:

a. Multimeter TS–352/U.

b. Four 47K, 2-watt resistors.

c. 45-volt B battery.

d. 115-volt, 60-cps source.

e. +250-volt d-c (B+) source (Power Supply PP–691/G or equivalent).

185. Filament Supply Trouble-shooting Procedure

The filament supply can be checked by taking simple voltage and resistance measurements.

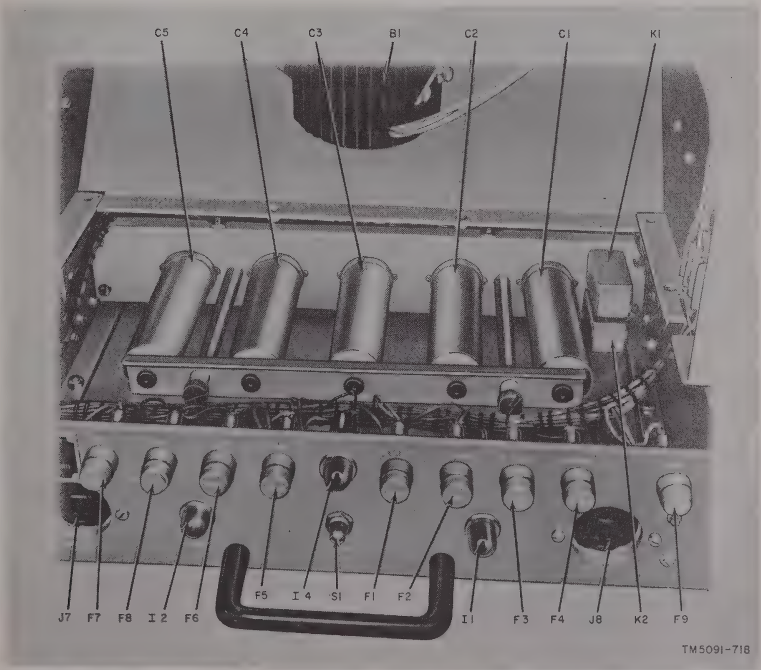


Figure 193. Filament supply, air filter removed, interior view.

186. Filament Supply Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the filament supply.

Symptom	Probable trouble	Correction
1. No 6.3 volts ac on mounting rack.	1. Faulty T1.	1. Replace T1.
	Faulty T2.	Replace T2.
	Short to ground on mounting rack.	Remove short.
	No 115-volt a-c input to T1 and T2.	Check input.
2. Inoperative blower.	2. Faulty blower (B1).	2. Replace B1.
	No 115 volts ac to input to blower (terminal lead off).	Check input.
3. Faulty alarm operation.	3. Faulty buzzer (I 3).	3. Replace I 3.
	Faulty S1.	Replace S1.
	Faulty K3.	Replace K3.
	Faulty K1 or K2.	Replace K1 or K2.
4. Faulty or inoperative remote keying operation.	4. P1 and/or P2 per channel not making good contact in connectors J1 and/or J2.	4. Repair or replace.
	Faulty K4, K5, K6, or K7 relay on remote keying units.	Replace K4, K5, K6, or K7.

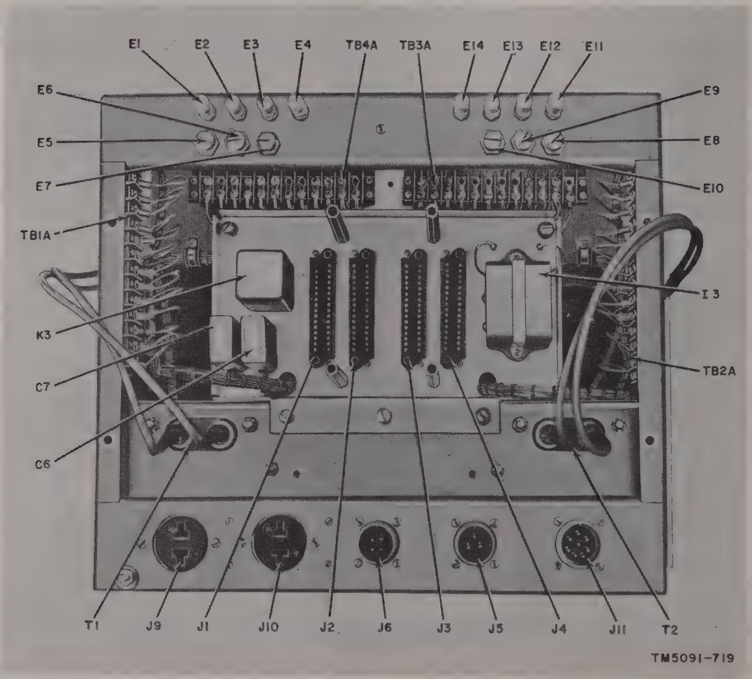

E1
E2
E3
E4
TB4A
TB3A
E14
E13
E12
E11
E6
E9
E5
E8
E7
E10
TB1A
I 3
K3
TB2A
C7
C6
T1
J9
J1
J10
J2
J6
J3
J5
J4
J11
T2
TM5091-719

Figure 194. Filament supply, back view, rear panel and remote keying units removed.

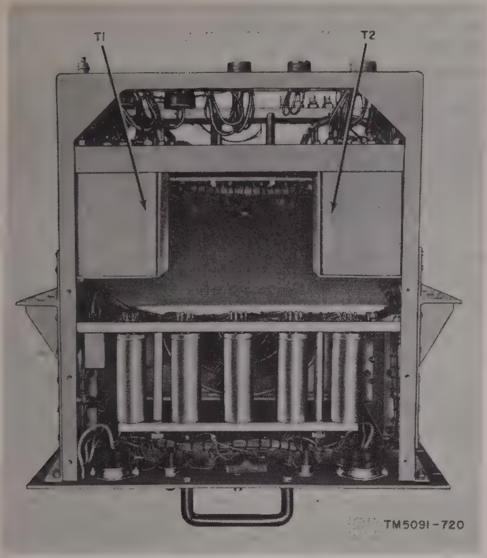


Figure 195. Filament supply, bottom view.

187. Filament Supply Tests

The following tests are helpful to localize trouble to a particular part within the filament supply.

Note. Connect a source of 115 volts ac across terminals 2 and 5 of TB4.

a. Filament Voltage at Full Load. Place the variable resistor across the secondary of each filament transformer (terminals 3 and 4), and vary the resistor until 30 amperes is drawn, for exactly 115 volts across the primary. Measure the secondary filament voltage with the vtvm. It should be 6.3 volts ±2 per cent.

b. Alarm Circuit. Check the alarm buzzer and alarm light by placing a short circuit across terminals 2 and 10 of TB4. The alarm buzzer should sound and the alarm light should light. Press the AUDIBLE ALARM DISCONNECT switch on the panel. The buzzer should no longer sound, but the light should remain on. Remove the a-c source for further tests.

Caution: These terminals have 115 volts ac across them in series with the buzzer.

c. B+ Disconnect Relays.

(1) Check B+ disconnect relays K1 and K2 by placing a short circuit between terminal 11 of TB2A and terminal 11 of TB1A. Put 45 volts dc from a B battery across terminal 7 of TB4A and ground (chassis).

(2) There should be a short circuit between the following terminals. Check with an ohmmeter.

Terminal	of terminal board	and terminal	of terminal board
1	TB3A	11	TB3A
2	TB3A	12	TB3A
3	TB3A	11	TB4A
4	TB3A	12	TB4A

(3) Remove the voltage from pin 7 of TB4A. There should now be open circuits between the above terminals.

d. Remote Keying Circuit.

(1) *General.* Make the following *temporary* connections:

(*a*) Ground (to chassis) terminals 5 of TB2A and TB1A.

(*b*) Place a short circuit between terminal 11 of TB2A and terminal 11 of TB1A.

(*c*) Place a 47K, 2-watt resistor from each of terminals 12 and 13 of TB1A to ground.

(*d*) Connect a source of B+ (250 volts dc) to B+ input connector J5.

Caution: Before making any of the wiring changes below, disconnect the power.

(2) *Normal operation.*

(*a*) Place the remote keying units in NORMAL OPERATION. There should be B+ voltage between the following terminals and ground (chassis).

Terminals	Terminal board
1	TB2A
2	TB2A
1	TB1A
2	TB1A

(*b*) Reconnect the 45-volt d-c sources between terminal 7 of TB4A and ground. There should be B+ voltage from both terminals 12 and 13 of TB2A to ground.

(*c*) Remove the ground from terminal 5, TB1A. This should remove the B+ voltage from both terminals 2 of TB2A and TB1A. Replace the ground.

(*d*) Remove the ground from terminal 5 of TB2A. This should remove B+ voltage from both terminals 1 of TB2A and TB1A. Replace the ground.

(*e*) Remove the two 47K resistors from terminals 12 and 13 of TB1A. There should be a short circuit between the following terminals:

Terminals	Terminal board
7 and 10	TB2
8 and 9	TB2
7 and 10	TB1
8 and 9	TB1

Caution: Replace the two 47K-ohm resistors before continuing.

(*f*) Connect a 47K, 2-watt resistor from each of terminals 12 and 13 of TB2A to ground. There should now be a short circuit between the following terminals:

Terminal	of terminal board	and terminal	of terminal board
9	TB3A	10	TB2A
9	TB3A	10	TB1A
10	TB3A	9	TB2A
10	TB3A	9	TB1A

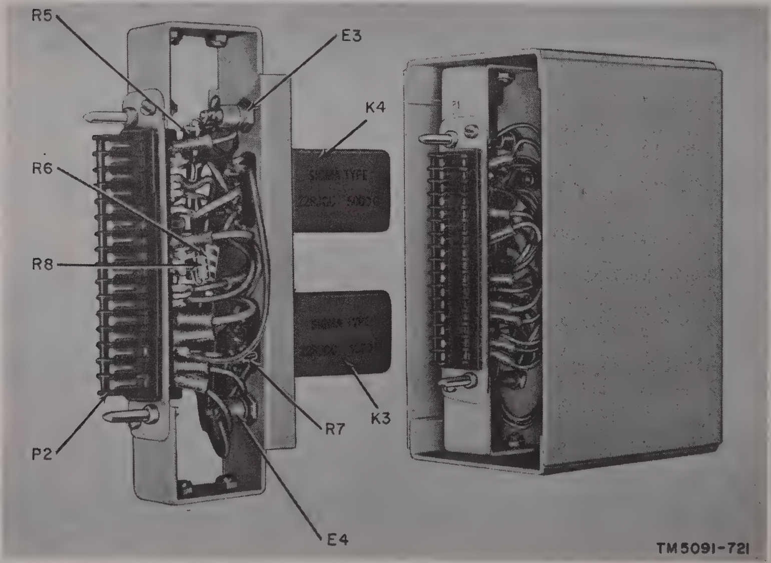


Figure 196. Remote keying unit.

(*g*) Remove the B+ voltage source and the 45-volt source. There should be a short circuit between the following terminals:

Terminal	of terminal board	and terminal	of terminal board
9	TB3A	3	TB1A
9	TB3A	3	TB2A
10	TB3A	4	TB1A
10	TB3A	4	TB2A

(3) *Remote keying operation.*

(*a*) Place the two remote keying units in REMOTE KEYING OPERATION. Reconnect the B+ voltage to J5.

(*b*) Place a short circuit between E13 and E14. There should be B+ voltage from terminal 1 of TB2A to ground, and there should be an open circuit between E11 and E12. Remove the short circuit. There should be no B+ on terminal 1 of TB2A, but E11 and E12 should still be open-circuited.

(*c*) Place a short circuit between E3 and E4. There should be B+ voltage from terminal 2 of TB2A to ground, and there should be an open circuit between E1 and E2. Remove the short circuit. There should be no B+ on terminal 2 of TB2A, but E1 and E2 should still be open-circuited.

(*d*) Measure the resistance across terminals 3 and 4 of TB1A and also across terminals 3 and 4 of TB2A. They should measure a nominal 600 ohms.

(*e*) Remove the 47K resistor from terminal 12 of TB2A. There should be a short circuit across E11 and E12. Replace the 47K resistor on terminal 12 of TB2A, and remove the 47K resistor on terminal 12 of TB1A. Again there should be a short circuit across E11 and E12. Replace the resistor.

(*f*) Remove the 47K resistor from terminal 13 of TB2A. There should be a short circuit across E1 and E2. Replace the 47K resistor on terminal 13 of TB2A, and remove the 47K resistor on terminal 13 of TB1A. Again there should be a short circuit across E1 and E2. Now remove all external connections.

e. Convenience Outlets, Fan, and Pilot Lights.

(1) With a 115-volt a-c source connected between terminals 2 and 5 of TB4A, the pilot lamp marked AC POWER should light, and the fan should rotate in the direction that blows air upward.

(2) With B+ voltage (250 volts dc) connected to pin C of J5, the pilot lamp marked +250V should light.

(3) Place the 115-volt a-c source across pins A and B of J6. There should be 115 volts ac on all the convenience outlets.

f. Continuity Checks. Remove all power from the unit. With an ohmmeter, check for continuity between the following points:

Terminal	Terminal board and Terminal		Jack
5	TB3A	A	J11
6	TB3A	B	J11
7	TB3A	C	J11
8	TB3A	D	J11
9	TB3A	E	J11
10	TB3A	F	J11
1	TB4A	D	J6
2	TB4A	D	J6
3	TB4A	D	J6
4	TB4A	C	J6
5	TB4A	C	J6
6	TB4A	C	J6
8	TB4A	C	J5
9	TB4A	Chassis	

Section VII. TROUBLE-SHOOTING POWER SUPPLY PP–691/G

188. Power Supply Trouble-shooting Data

The following references will assist maintenance personnel in trouble shooting the power supply.

Fig. No.	Description
145	Power Supply PP–691/G, block diagram.
269	Power Supply PP–691/G, over-all schematic diagram.
284	Power Supply PP–691/G, over-all wiring diagram.
197	Power supply, interior view.
198	Power supply, top view.
199	Power supply, bottom view.
200	Power supply, back view.

189. Test Equipment Required for Power Supply

The following test equipment is required when trouble shooting the power supply:

Item	Technical manual
Electronic Multimeter ME–6C/U	TM 11–5549B
Electronic Multimeter TS–505/U	TM 11–5511
Multimeter TS–352B/U	TM 11–5527A
Variable resistors (2-ampere rating, 0-600 ohms; 20-ampere rating, 0-50 ohms)	
D-c ammeter, 1.5 to 3 amperes, full scale.	
A-c ammeter, 7.5 to 30 amperes, full scale.	

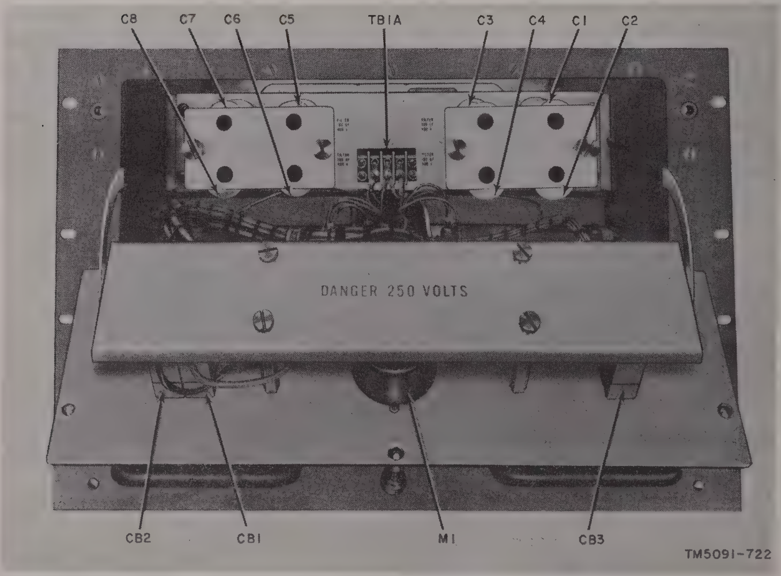


Figure 197. Power supply, interior view.

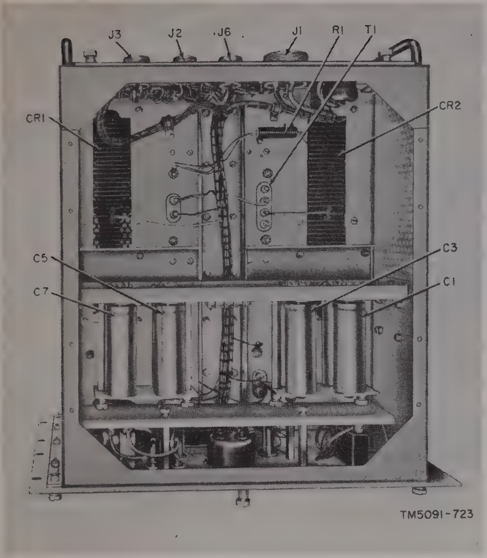


Figure 198. Power supply, top view.

190. Power Supply Trouble-shooting Procedure

The power supply can be serviced by taking simple voltage and resistance measurements. The power supply is a full-wave, bridge rectifier-type with choke-input filter. The bridge rectifier uses selenium rectifiers.

a. The tests below are helpful to localize trouble to a particular part within the power supply. Connect the power supply to a 115-volt regulated a-c source.

Caution: Never handle a burned-out selenium rectifier with the bare hands. Use either tools or gloves to handle the rectifier.

b. B+ Voltage at Full Load.

(1) Connect one side of the variable resistor (0 to 600 ohms) to pin C of +250V OUTPUT jack J2.

(2) Connect the other side of the variable resistor to the positive terminal (+) of the d-c ammeter (1.5 to 3 amperes full scale).

(3) Connect the negative terminal (–) of the ammeter to terminal B of +250V OUTPUT jack J2.

Caution: Be sure that the variable resistor is set for maximum resistance.

(4) Apply power to the power supply.

(5) Decrease the value of the variable resistor until a reading of 1.6 amperes is obtained on the ammeter. (This is full load.)

(6) Measure the B+ voltage across the variable resistor with Electronic Multimeter TS–505/U, or equivalent. The reading obtained should be 250 volts ±10 volts.

c. Ripple Voltage at Full Load.

(1) Connect the equipment as outlined in subparagraph *b* (1) through (5) above.

(2) Measure the ripple voltage at full load (1.6 amperes) with Electronic Multimeter ME–6C/U. The average reading should not be greater than 40 millivolts.

d. Regulation.

(1) Connect the equipment as outlined in subparagraph *b*(1) through (4) above.

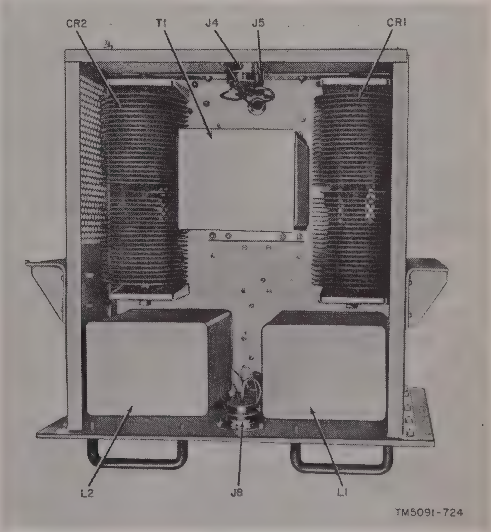


Figure 199. Power supply, bottom view.

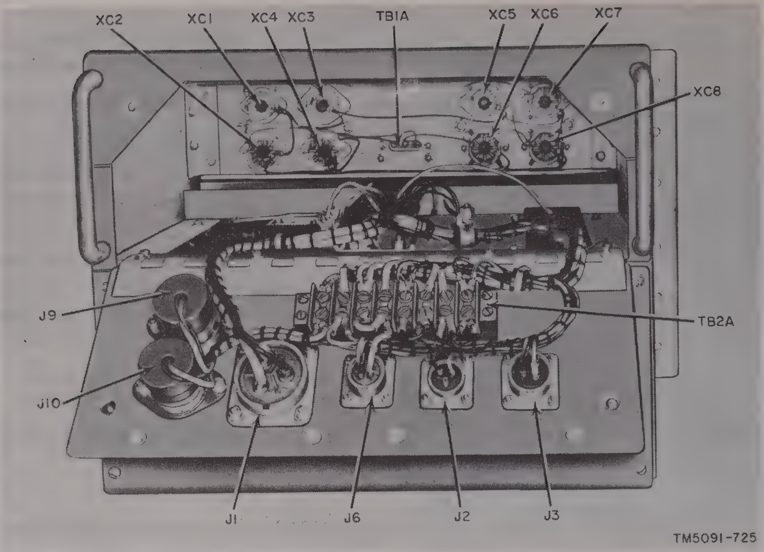


Figure 200. Power supply, back view.

(2) Decrease the value of the variable resistor until a reading of .5 ampere is obtained on the ammeter.

(3) Measure the B+ voltage across the variable resistor with Electronic Multimeter TS–505/U. The reading obtained should be no greater than +285 volts.

e. Convenience Outlets, Meters, and Pilot Lights. Check all convenience outlets, meters, and pilot lights for proper operation. Check for 115 volts ac between pins A and B of J6 and pins C and D of J3. Check for 250 volts dc between pins A and B of J3 and pins B and C of J2. Pin A of J3 and pin B of J2 should be positive.

Note. A 10 per cent voltage increase is available on the plate transformer to account for a possible selenium rectifier change after 1 operating year.

f. Circuit Breaker Operation.

(1) *Main circuit breaker.*

(*a*) With the input power disconnected, insert a variable resistive load (0 to 50 ohms, 20-ampere rating) in series with a 30-ampere a-c ammeter across terminals B and C of J4 or B and C of J5.

(*b*) Turn the +250V switch off. Connect input power and turn on the main circuit breaker.

(*c*) Gradually reduce the load resistance from full resistance until circuit breakers CB1 and CB2 open.

(*d*) The cutout current should be no less than 15 amperes and no greater than 18.75 amperes.

(*e*) Remove the load resistor.

(2) *+250-volt circuit breaker.*

(*a*) With the input power disconnected, insert a variable resistive load (0 to 600 ohms, 2-ampere rating) across terminals J2B and J2C.

(*b*) Insert a 7.5-ampere a-c ammeter in series with the a-c input source.

(*c*) Turn on the filament and +250-volt switches.

(*d*) Gradually reduce the load resistance from full resistance until circuit breaker CB3 opens.

(*e*) The cutoff current should be no less than 6 amperes nor greater than 7.5 amperes.

191. Power Supply Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the power supply:

Symptom	Probable trouble	Correction
1. B+ about 10 per cent low.	1. Aged CR1.	1. Change transformer tap.
2. B+ more than 10 per cent low.	2. Faulty CR1.	2. Replace CR1.
3. No B+ output at terminal 2 of TB2A.	3. Short to ground on pin C of J2. CR1 faulty. Faulty T1. Open L1. Open L2. Shorted filter capacitors C1 through C8.	3. Remove short. Replace CR1. Replace T1. Replace L1. Replace L2. Replace defective capacitor.
4. Increase in B+.	4. Shorted L1. Shorted L2.	4. Replace L1. Replace L2.
5. Increase in output ripple voltage.	5. Open capacitors C1 through C8. Shorted L1 and/or L2.	5. Replace defective capacitor. Remove short or replace L1 and/or L2.

Section VIII. TROUBLE-SHOOTING OSCILLOSCOPE OS–25/G

192. Oscilloscope Trouble-shooting Data

The following references will assist maintenance personnel in trouble shooting the oscilloscope.

Fig. No.	Description
266	Oscilloscope OS–25/G, over-all schematic diagram.
281	Oscilloscope OS–25/G, over-all wiring diagram.
201	Oscilloscope, left side view.
202	Oscilloscope, right side view (looking down).
203	Oscilloscope, right side view (looking up).
204	Oscilloscope, rear view.
205	Oscilloscope, back of front panel, right side view.
206	Oscilloscope, front panel swung down.
232 through 234	Oscilloscope, tube socket voltage and resistance diagrams.

193. Test Equipment Required for Oscilloscope

The following test equipment is required to fully test the oscilloscope.

Item	Technical manual
Square Wave Generator TS–583/U.	TM 11–5024
Multimeter TS–352/U.	TM 11–5527A
Electronic Multimeter TS–505/U.	TM 11–5511
Signal Generator SG–71/FCC.	TM 11–5088
Frequency Meter FR–67/U.	TM 11–2698
Voltmeter ME–30A/U.	
Signal Generator AN/URM–25B.	TM 11–5551A
Oscilloscope OS–8A/U.	

194. Checking Oscilloscope Filament and B+ Circuits

Trouble within the unit often may be detected by checking the resistance of the filament and high-voltage circuits before applying power to the equipment, to prevent damage to the power supply.

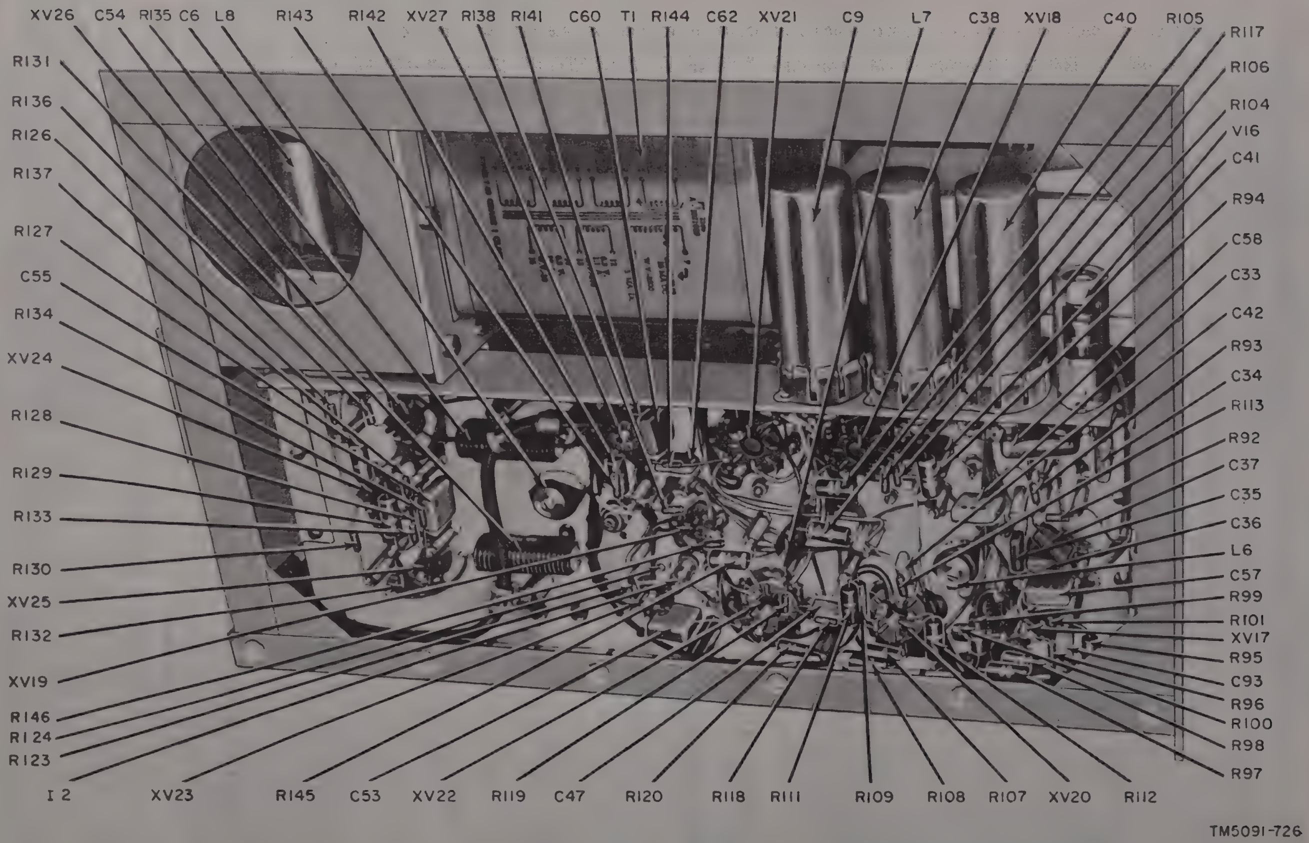

XV26
C54
R135
C6
L8
R143
R142
XV27
R138
R141
C60
T1
R144
C62
XV21
C9
L7
C38
XV18
C40
R105
R131
R136
R126
R137
R127
C55
R134
XV24
R128
R129
R133
R130
XV25
R132
XV19
R146
R124
R123
I 2
XV23
R145
C53
XV22
R119
C47
R120
R118
R111
R109
R108
R107
XV20
R112
R117
R106
R104
V16
C41
R94
C58
C33
C42
R93
C34
R113
R92
C37
C35
C36
L6
C57
R99
R101
XV17
R95
C93
R96
R100
R98
R97
TM5091-726

Figure 201. Oscilloscope, left side view.

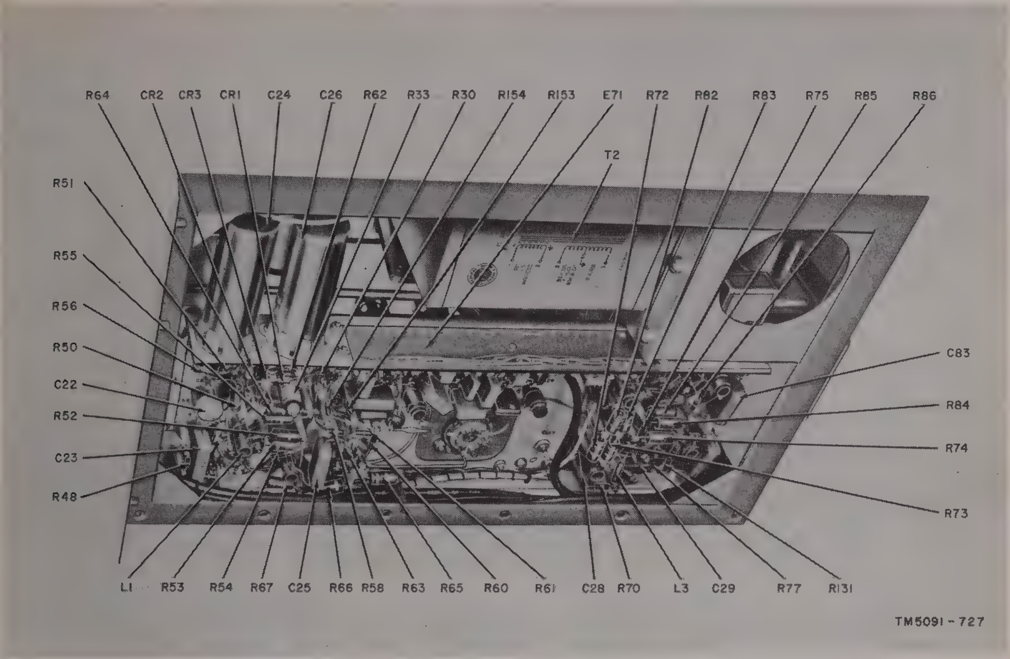

R64
CR2
CR3
CR1
C24
C26
R62
R33
R30
R154
R153
E71
R72
R82
R83
R75
R85
R86
T2
R51
R55
R56
R50
C22
R52
C23
R48
C83
R84
R74
R73
L1
R53
R54
R67
C25
R66
R58
R63
R65
R60
R61
C28
R70
L3
C29
R77
R131
TM5091-727

Figure 202. Oscilloscope, right side view (looking down).

195. Oscilloscope Terminal Socket Voltages and Resistances

The normal d-c voltages (and rms voltages where indicated) between the tube socket and terminals and the chassis ground as measured by a vacuum tube voltmeter are shown in figures 232 through 234. A-c line voltage was held constant at 115 volts and a 6-volt peak-to-peak, 8-kc signal was applied from the video restorer sync jack. The oscilloscope controls are set as follows:

Control	Position or adjustment	Control	Position or adjustment
HOR POSITION	Trace centered	CAL VOLTAGE	10
VERT POSITION	Trace centered	ASTIG	Sharpest trace
SWEEP PHASE	Pointer vertical	VERT ATTEN	1:1
FOCUS	Sharpest trace	VERT GAIN	Maximum
SYNC SELECTOR	MULTIPLEXER	STAB	Slightly counterclockwise from recurrent sweep
COARSE	5	TRIGGER	Clockwise until triggered
FINE	10	PIP LOCKING	Clockwise until locked
TIMING PIP PHASE	Fully clockwise	PROBE	Grounded
INTENSITY	Maximum		

Note. The values given are typical for an input signal giving less than a 2-cm peak-to-peak trace and 192-kc timing pips superimposed on the cathode-ray tube face and they may vary by +10 per cent.

196. Oscilloscope Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the oscilloscope.

Symptom	Probable trouble	Correction
1. No power.	1. Switch off.	1. Turn on.
	Plug out.	Plug in.
	Fuse blown.	Replace fuse.
2. No trace.	2. T1 open between terminals 7 and 9.	2. Replace T1.
	Open C61.	Replace C61.
	Neon tubes on E115 open on both sides.	Replace neon tubes I 3 through I 12.
	Open L7.	Replace L7.
	Faulty —140-volt supply.	Check V8 and V11 and associated components.
	Faulty +225-volt or +450-volt supply.	Check paragraph 94.
3. Low intensity.	3. Faulty C61.	3. Replace C61.
	Faulty +1,500-volt supply.	Check V2 and associated components (par. 94).
	Weak crt.	Replace crt.
	H-v, cap off crt.	Replace cap.
	Faulty –1,800-volt supply.	Check V1 and associated components.
4. No vertical signal.	4. Open attenuator probe.	4. Repair probe.
	Open L1.	Replace L1.
	Open L4.	Replace L4.
	Open L3.	Replace L3.
	Open L5.	Replace L5.
	Faulty S2.	Replace S2.
	Faulty VERT GAIN potentiometer R68.	Replace R68.
5. Vertical calibration incorrect.	5. Faulty CR1, CR2, or CR3.	5. Replace CR1, CR2, or CR3.
	Trimmer capacitor on input attenuator misadjusted.	Adjust properly. Refer to paragraph 197*g*(6).
	Faulty R35.	Replace R35.
	Faulty L2, L12, or L13.	Replace L2, L12, or L13.
6. No calibration voltage.	6. CR2 or CR3 shorted.	6. Replace CR2 or CR3.
	CR1 open.	Replace CR1.
	Open R35.	Replace R35.
7. Shortened trace.	7. Open connection between I 3 through I 7 or I 8 through I 12.	7. Repair connections.
	Faulty —140-volt supply.	Check above.
8. None or poor sync of trace.	8. Faulty —140-volt supply.	8. Check above.
	Faulty autosysn.	Replace autosysn.
	Open L6.	Replace L6.
	Open L8.	Replace L8.
	Improper kc voltage.	Check oscillator.
9. Timing pips will not lock and/or phase properly.	9. No 8-kc sync.	9. Check V1.
	Faulty —140-volt supply.	Check above.
	8-kc sync improper voltage.	Adjust sync voltage. Refer to paragraph 197*d*(6).
	Open L9.	Replace L9.
	Faulty CR4.	Replace CR4.
	L10 improperly adjusted for correct bias and corrected timing.	Adjust L10.
	L11 open.	Replace L11.
	CR5 faulty.	Replace CR5.

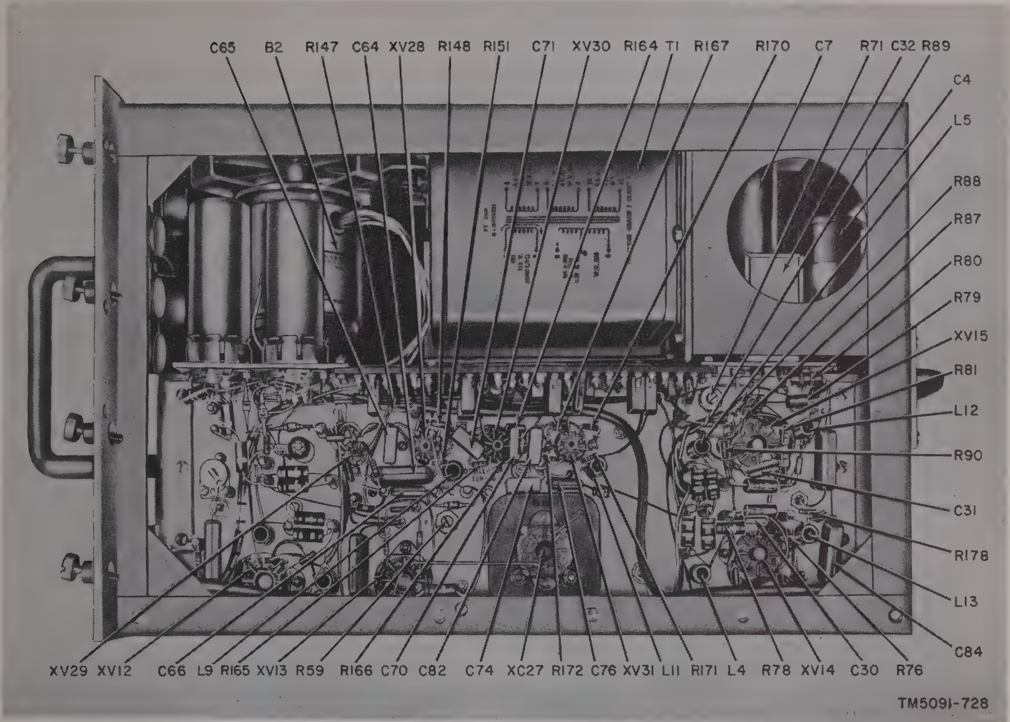

C65
B2
R147
C64
XV28
R148
R151
C71
XV30
R164
T1
R167
R170
C7
R71
C32
R89
C4
L5
R88
R87
R80
R79
XV15
R81
L12
R90
C31
R178
L13
C84
XV29
XV12
C66
L9
R165
XV13
R59
R166
C70
C82
C74
XC27
R172
C76
XV31
L11
R171
L4
R78
XV14
C30
R76
TM5091-728

Figure 203. Oscilloscope, right side view (looking up).

197. Oscilloscope Tests

The tests in subparagraphs *a* and *j* below are included for reference and as a test procedure after major repair or rebuilding. First, connect a source of 60-cycle, 115-volt power to the scope. Then allow the scope to warm up for 1 minute.

Note. The oscilloscope requires 300 watts.

a. Power Supply Voltages.

(1) *Measurements.* All the oscilloscope power supply voltages (including the filament voltages) should be measured. The voltages to be measured and tolerances required are given below.

Note. To achieve the accuracy required for the +225-volt and the following +450-volt adjustments, the multimeter should be calibrated carefully against a 1 per cent standard at +225 volts dc and +250 volts dc.

Location	Nominal voltage	Tolerance
Pin 3 of V9 (note adjustment procedure below).	+225 volts dc	+3 volts dc
Pin 2 of V4 (note adjustment procedure below).	+450 volts dc	+5 volts dc
Filament voltages between pins 2 and 7 of V12 and V17, and pins 3 and 4 of V10.	6.3 volts ac	+2%
Ungrounded side of C3.	– 1,500 volts dc	+150 volts dc
Cathode-ray tube, high-voltage cap (cap side of R5) or E16.	+1,800 volts dc	+150 volts dc
Pin 1 of TB1A	– 140 volts dc	+5 volts dc
Junction of R183 and R182.	– 600 volts dc	+50 volts dc

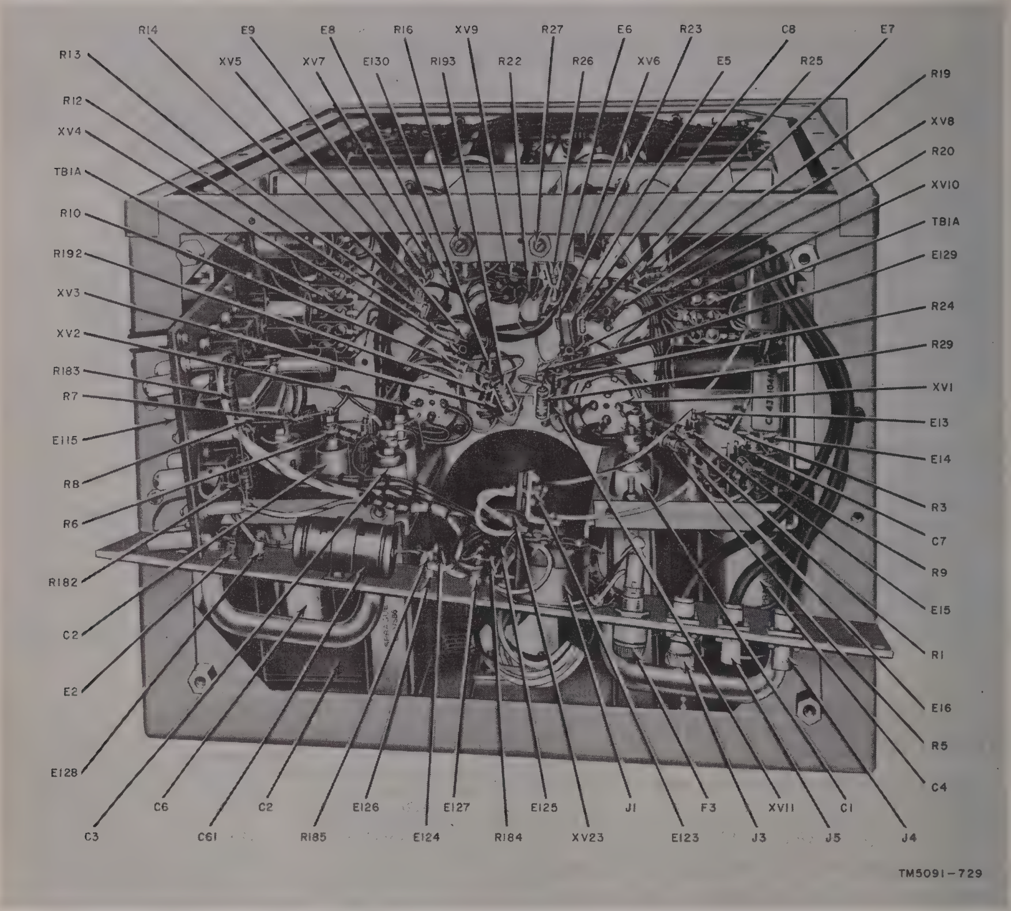

R14
E9
E8
R16
XV9
R27
E6
R23
C8
E7
R13
XV5
XV7
E130
R193
R22
R26
XV6
E5
R25
R19
R12
XV8
XV4
R20
TB1A
XV10
R10
TB1A
R192
E129
XV3
R24
XV2
R29
R183
XV1
R7
E13
E115
E14
R8
R3
R6
C7
R182
R9
E15
C2
R1
E2
E16
R5
E128
C4
C6
C2
E126
E127
E125
J1
F3
XV11
C1
C3
C61
R185
E124
R184
XV23
E123
J3
J5
J4
TM5091-729

Figure 204. Oscilloscope, rear view.

(2) *Adjustment of +225-volt supply.* The +225-volt supply must be set within +3 volts. This should be checked and adjusted if necessary by varying +225V DC ADJ potentiometer R27, at the back of the scope (fig. 204). This check should be made if voltage regulator tube OA2 (V11) is changed. The +450-volt supply should always be adjusted *after* making a +225-volt adjustment. It is adjustable by varying +450V DC ADJ potentiometer R16, at the back of the scope (fig. 204).

Caution: The +450-volt supply should never be adjusted without first adjusting the +225-volt supply.

b. Timing-marker Generator.

(1) Connect the output of Signal Generator SG–71/FCC to MULTIPLEXER SYNC INPUT jack J4. Set the signal generator for a 20-volt, 8-kc output.

(2) Set the panel controls on the oscilloscope as indicated below:

Control	Position
SYNC SELECTOR	DEMTPX
COARSE	5
FINE	2
INTENSITY	Clockwise (normal brightness)
HOR POSITION	Middle of range
VERT POSITION	Middle of range
TIMING PIP PHASE	Middle of range
VERT ATTEN	1:1
VERT GAIN	Two-thirds clockwise
TRIGGER	Fully counterclockwise
STAB	Fully counterclockwise

(3) Advance the STAB control until a trace appears and then turn it in the opposite direction until the sweep just disappears.

(4) Advance the TRIGGER control until the trace reappears. This trace may not be synchronized, and thus may not remain stationary on the screen.

(5) Slowly turn the PIP LOCKING control until the trace remains stationary. If it is not possible to synchronize the trace, follow the procedure given in subparagraph (7) below.

(6) If the trace remains stationary, it should consist of timing pips spaced 5.2 microseconds apart. Vary the TIMING PIP PHASE slowly. It should be possible to move the pips at least 6 microseconds.

(7) If it should become impossible to lock the pips with the PIP LOCKING control, proceed as follows for adjusting the timing-marker generator:

(*a*) Attach Electronic Multimeter TS–505/U to the center tap of potentiometer R161.

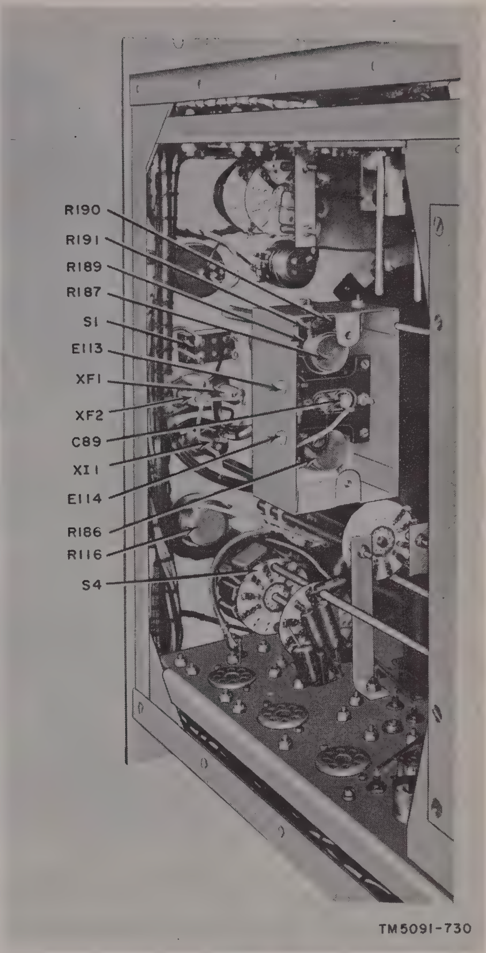


Figure 205. Oscilloscope, back of front panel, right side view.

(*b*) Adjust the PIP LOCKING control until the voltmeter reads —2.4 volts dc; then remove the voltmeter.

(*c*) Attach the scope probe to E37 (near V29).

(*d*) Adjust the COARSE and FINE controls until two negative pulses (8-kc repetition rate) appear on the screen. The timing pips will be superimposed on these negative 8-kc pulses as shown in figure 206.

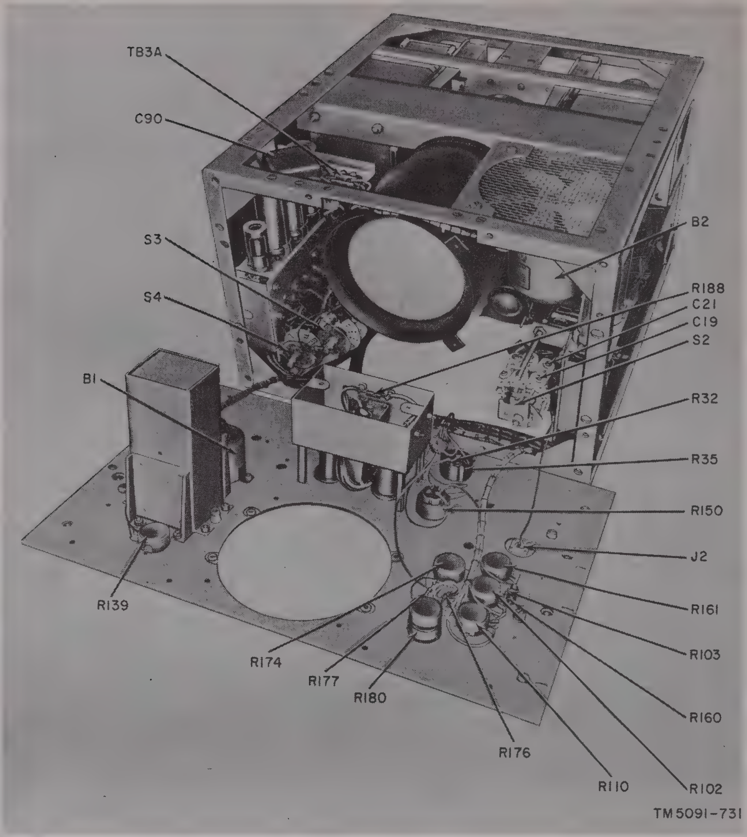


Figure 206. Oscilloscope, front panel swung down.

(*e*) Loosen the locknut on L10. Be sure that the coil mounting nut is on tight.

(*f*) Adjust L10 until the 192-kc pips remain stationary.

(*g*) The pips should divide the time between the two negative pulses into exactly 24 equal intervals. If there are more or less than 24 intervals, readjust L10.

Note. It is essential that the 8-kc sync be 8 kc ±.01. Frequency Meter FR–67/U should be used to monitor the output frequency of Signal Generator SG–71/FCC.

(*h*) Tighten the locknut without disturbing the adjustment.

(*i*) Recheck the —2.4-volt adjustment as follows: Repeat the procedures given in subparagraphs (1) through (5) above, turn the PIP LOCKING control fully counterclockwise and advance in the clockwise direction very slowly until the pips just become synchronous. The voltage at the center tap of R161 or from R159 to ground should be —2.4 +.2 volts dc. Remove the probe from E37.

(8) Turn the autosyn in either direction. The timing pips should be moved continuously across the screen as the control is turned.

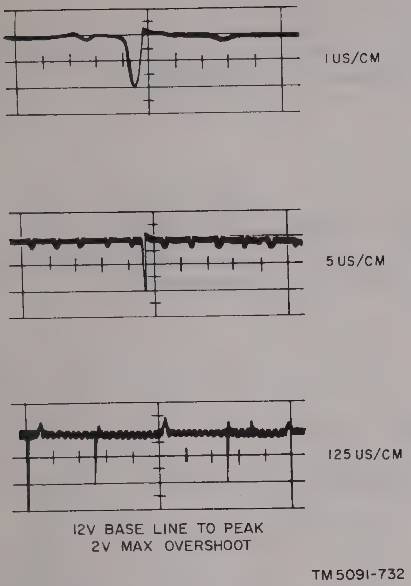


Figure 207. Wave form at pin 6 (plate) of V28B.

c. Calibration of Sweep Speed. The oscilloscope has an accurate time base calibration consisting of timing pips; therefore, it is not necessary that the COARSE and FINE controls be accurately calibrated. The maximum sweep speed of .5 microsecond per centimeter is sufficiently useful, if sweep speed calibrating potentiometer R124 is adjusted specifically to be sure this speed is available. To make this calibration, proceed as follows:

(1) Provide an 8-kc sync from Signal Generator SG–71/FCC and turn on the timing markers (previously calibrated).

(2) Place the COARSE control in the 5-microsecond position and the FINE control to 1.

(3) Adjust R124 (fig. 201) until two consecutive timing pips are 11 centimeters apart. The maximum speed is now in excess of the desired .5 microsecond per centimeter.

(4) Retighten the locking nut on R124. Check to see that the COARSE and FINE controls operate in all positions as follows:

(*a*) Set the COARSE and FINE controls as shown in the table below.

(*b*) Connect the scope probe to the output of Signal Generator SG–71/FCC. Switch scope SYNC SELECTOR to +INT and TIMING PIP PHASE to OFF.

(*c*) Adjust the frequency of the oscillator so that 1 complete cycle covers 10 cm on the scope phase. This will be the frequency given in the *Nominal frequency* column.

Sweep time		Nominal frequency	Sweep overlap
Coarse	Fine		
5000	10	30 cps	
5000 500	1 10	300 cps	≥ 20 cps
500 50	1 10	2.8 kc	≥ 200 cps
50 5	1 10	23 kc	≥ 1 kc

(*d*) To insure a complete and continuous range of sweep speeds, there must be an overlap in the sweep speed when switching the sweep time from one scale to another. The amount that the scales should overlap is given in the *Sweep overlap* column. The scales that should overlap are bracketed and the overlap should be such that the higher sweep time setting should have the higher frequency (that is, setting 50-1 should have a higher frequency than 5-10). To make the above procedure clearer, assume that the COARSE and FINE controls are in positions 5 and 10, respectively. The oscillator frequency is adjusted until 1 complete cycle covers 10 cm. Assume that this frequency is 20 kc. Switch the COARSE and FINE controls to 50 and 1, respectively. The frequency of the oscillator is again adjusted so that 1 cycle covers 10 cm. This new frequency must be at least 21 kc or greater.

(*e*) Connect J3 to the test oscillator and place the SYNC SELECTOR control in +EXT position. Use the STAB and TRIGGER controls to obtain a stable trace.

(*f*) Repeat the procedure given in subparagraph (*d*) above with the SYNC SELECTOR control in —EXT position.

d. Adjustment of Vertical Amplifier Low Frequency Response. To adjust the low frequency response of the vertical amplifier, proceed as follows:

(1) Set the VERT ATTEN control to 1:1 and the SYNC SELECTOR control to +INT, the COARSE switch to 5000 and the FINE control to 10.

(2) Apply a 50-cycle, 5-volt square wave to the probe, from Square Wave Generator TS–583/U.

(3) Adjust R59 and R71, located on the right side chassis (fig. 203), until a flattop is obtained (fig. 208). This same figure also indicates the effect of incorrect adjustment of these potentiometers.

(4) Set the VERT ATTEN switch to CAL. The wave form should have a flattop (fig. 208).

(5) To check the SYNC SELECTOR control, switch it to —INT. The trace should be 180° out of phase with the +INT trace.

e. Adjustment of Input Attenuator. To compensate for the probe on each attenuator setting, variable capacitors are provided across the input to each divider. The most convenient way to adjust these capacitors is to observe the resulting waveshape on the oscilloscope when supplying the input with a 1,000-cycle square wave that is adjustable from 1 to 50 volts peak to peak. Proceed as follows:

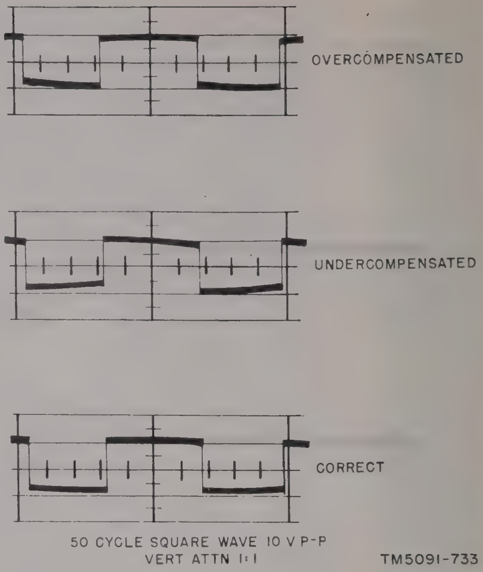


Figure 208. Vertical amplifier adjustment wave form.

(1) Set the COARSE control to 5000, the FINE control to 2, and the SYNC SELECTOR switch to +INT.

(2) Set the VERT ATTEN switch to 1:1 and the VERT GAIN control two-thirds clockwise and, with the probe, apply a 5-volt, 1,000-cycle square wave to the scope.

(3) Adjust C22 (located on the vertical amplifier chassis, fig. 202) for the best wave form on the screen (fig. 210).

(4) Set the VERT ATTEN switch to 2:1 and apply a 10-volt, 1,000-cycle square wave to the probe.

(5) Adjust C19 and C21 on VERT ATTEN switch S2 (fig. 206) for best wave form (fig. 211 and 212). These same figures also indicate the wave forms to be expected when C19 and C21 are not properly adjusted.

(6) Set the VERT ATTEN switch to 10:1 and apply a 50-volt, 1,000-cycle square wave to the probe.

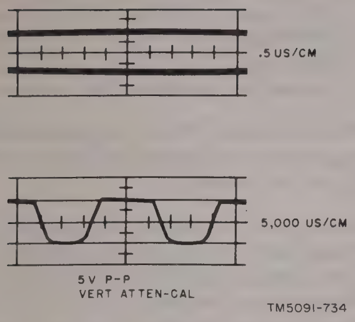


Figure 209. Vertical attenuator adjustment wave form and crt display, voltage calibrator wave form.

(7) Adjust C16 and C17 as indicated in subparagraph (5) above.

(8) Set the VERT ATTEN switch to 100:1 and apply a 50-volt, 1,000-cycle or larger square wave to the probe.

(9) Adjust C11 and C13 as indicated in subparagraph (5) above.

f. Voltage Calibrator. To check the voltage calibrator accuracy, proceed as follows:

(1) Apply a 100-cycle square wave of known voltage to the probe.

(2) Adjust the VERT GAIN control until the square wave is of a size which corresponds to two boxes in amplitude on the graticule. *Note the VERT ATTEN setting.*

(3) Set the VERT ATTEN switch on CAL and adjust the trace with the CAL VOLTAGE control until its size corresponds to two boxes on the graticule.

(4) Multiply the reading on CAL VOLTAGE control by the VERT ATTEN setting noted in subparagraph (2) above. This answer should give the value of the known voltage within 10 per cent.

(5) Apply this procedure in every setting of the VERT ATTEN switch.

Caution. Do not adjust the FOCUS, INTENSITY, or ASTIG control while making voltage calibration tests.

g. Vertical Amplifier Bandwidth.

(1) Connect the unbalanced output terminals of Signal Generator AN/URM-25B to the scope probe.

(2) Connect Voltmeter ME-30A across these terminals.

(3) Rotate the SYNC SELECTOR switch to +INT and the VERT ATTEN control to 1:1.

(4) Set the signal generator frequency at 100 kc and adjust its output to 1.5 volts. This may be considered as the reference or 0 db level.

(5) Adjust the VERT GAIN control for either a 1-division or a 2-division sine wave, preferably 2, depending on the scope sensitivity. If necessary, adjust the vertical position control to bring the top of the sine wave to the top of the division mark on the scope scale. This can be considered the division marker reference level.

(6) Set the signal generator frequency to 60 cps and adjust the output to the division marker reference level.

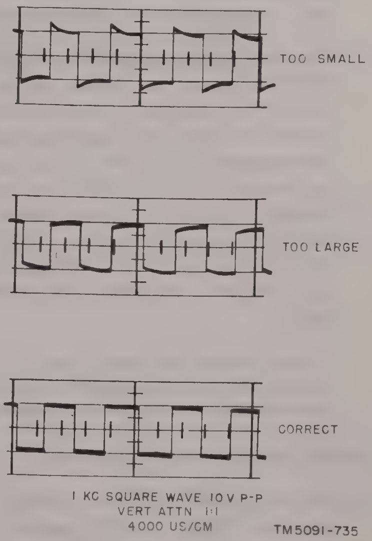


Figure 210. Capacitor C22 adjustment wave form.

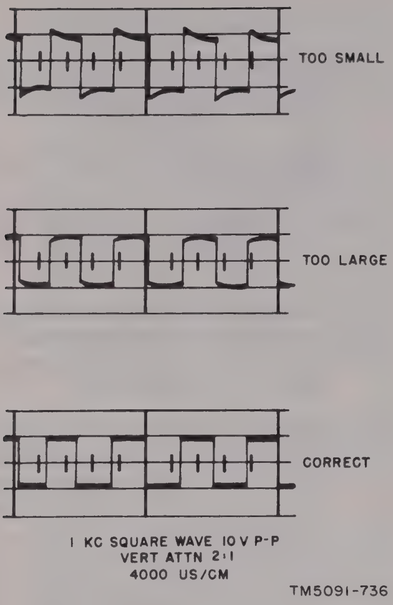


Figure 211. Vertical attenuator adjustment, C19 wave form.

(7) Note the oscillator voltage. The reading should be from 1.43 to 1.57 volts, corresponding to —.4 db and +.4 db, with respect to the reference level.

(8) Disconnect the Signal Generator SG-71/FCC from the scope probe and substitute Signal Generator AN/URM-25B. Set the signal generator frequency to 5MC and adjust its output to bring the top of the wave to the division marker reference level. The signal generator reading should be from 1.42 to 2.12 volts corresponding to .5 db to 3 db from the reference level.

Note. Other convenience values of voltage may be used throughout as long as the relative decibel values are maintained.

h. Maximum Deflection Sensitivity.

(1) Set the VERT ATTEN control to 1:1 and the VERT GAIN control fully clockwise.

(2) Insert a signal to the scope probe from the square wave generator. Increase the signal until there is a vertical deflection of 1 cm on the scope face. This signal voltage should be 3 volts or less.

i. Fan Operation. With the oscilloscope on, the fan should be blowing air upwards and out of the top of the scope.

j. Wave Forms. If the above test shows that the oscilloscope is not operating properly, check the wave forms at the points indicated in the chart below. Use Oscilloscope OS-8A/U or another Oscilloscope OS-25/G for this purpose. Change the tube of the stage which appears defective; if this does not correct the fault, check the circuit components.

(1) *Horizontal amplifier (input 1-kc square wave, 10 volts p-p).*

Pin	Tube	Fig. ref
8	V12	213
8	V13	214
8	V14	215
8	V15	216

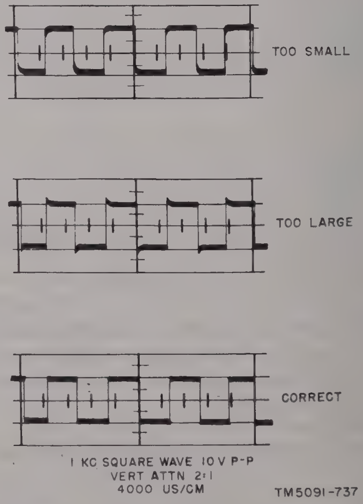


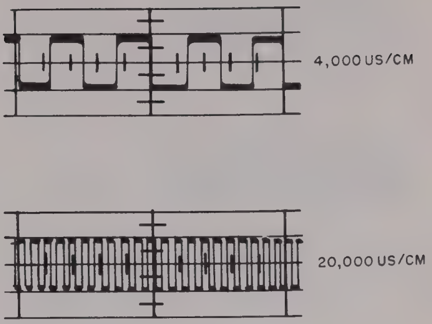
Figure 212. Vertical attenuator adjustment, C21 wave form.

(2) *Horizontal amplifier (triggered).*

Pin	Tube	Fig. ref
1	V16A	217
6	V16B	218
5, 8	V17	219
8	V18	220
5	V19A	220
8	V20	221
8	V21	222
8	V22	223
1, 5	V24	223
5	V25	224
5	V26	225
1	V28A	226
6	V28B	207
1, 6	V30	227
7	V30B	228
6	V31A	229
J4		230

(3) *Voltage calibration circuit.* Observe the cathode-ray tube display. Check the crt display to see that it is similar to the one shown in figure 209.

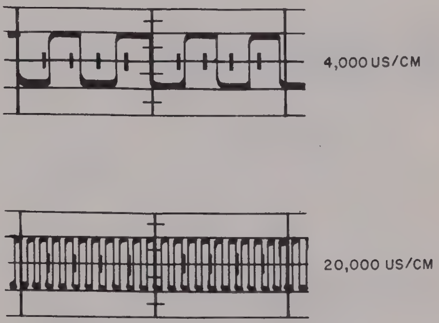
(4) *Time calibration.* Observe the cathode-ray tube display. Check the crt display to see that it is similar to the one shown in figure 231.



1 KC SQUARE WAVE
14V P-P (10V P-P INTO PROBE)
VERTICAL ATTENUATION 1:1

TM5091-738

Figure 213. Wave form at pin 8 (plate) of V12.



1 KC SQUARE WAVE
9V P-P(10V P-P INTO PROBE)
VERTICAL ATTENUATION 1:1

TM5091-739

Figure 214. Wave form at pin 8 (plate) of V13.

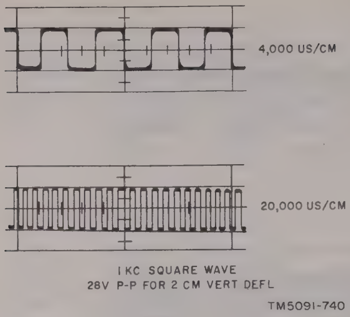


Figure 215. Wave form at pin 8 (plate) of V14.

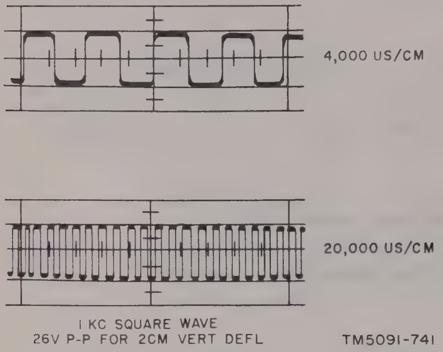


Figure 216. Wave form at pin 8 (plate) of V15.

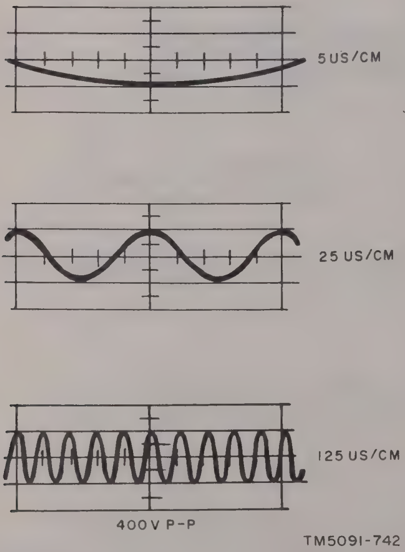


Figure 217. Wave form at pin 1 (plate) of V16A.

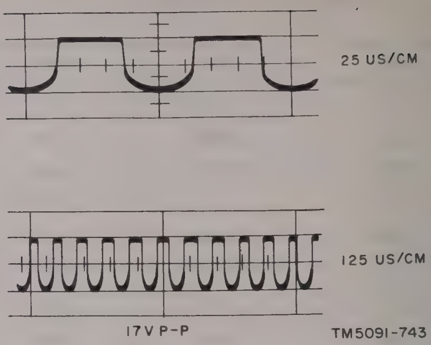


Figure 218. Wave form at pin 6 (plate) of V16B.

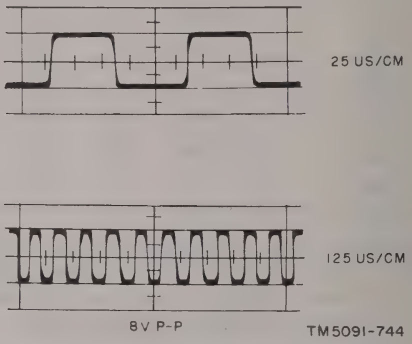


Figure 219. Wave form at pins 5 (cathode) and 8 (plate) of V17.

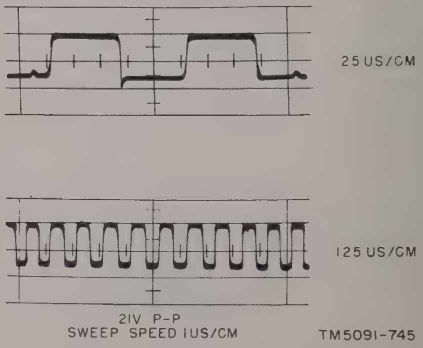


Figure 220. Wave form at pin 8 (plate) of V18 and pin 5 (cathode) of V19A.

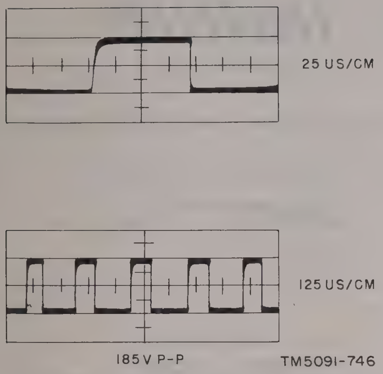


Figure 221. Wave form at pin 8 (plate) of V20.

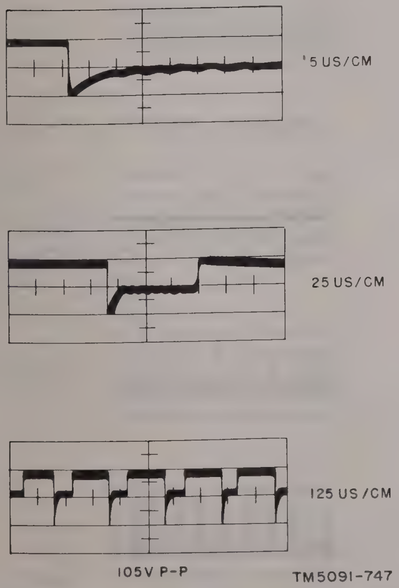


Figure 222. Wave form at pin 8 (plate) of V21.

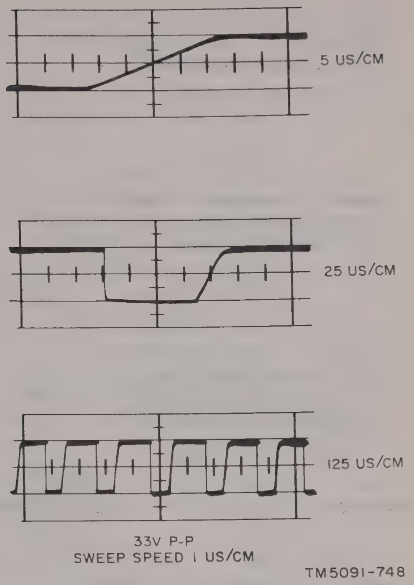


Figure 223. Wave form at pin 8 (plate) of V22 and pins 1 and 5 (cathode) of V24.

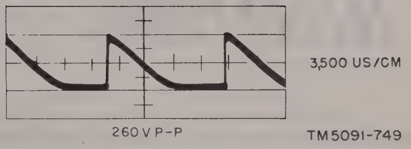


Figure 224. Wave form at pin 5 (plate) of V25.

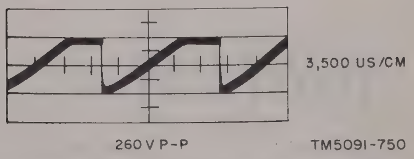


Figure 225. Wave form at pin 5 (plate) of V26.

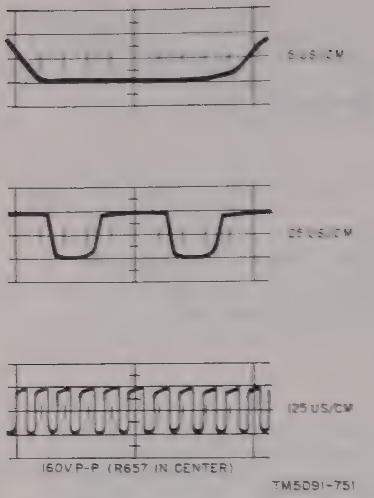


Figure 226. Wave form at pin 1 (plate) of V28A.

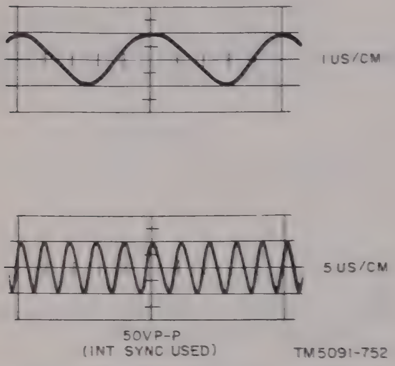


Figure 227. Wave form at pins 1 and 6 (plates) of V30.

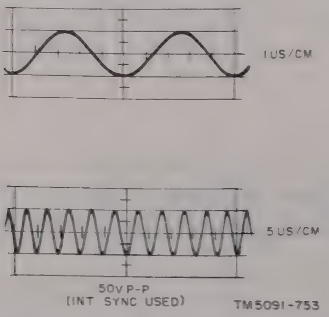


Figure 228. Wave form at pin 7 (grid) of V30B.

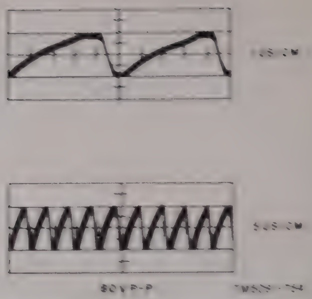


Figure 229. Wave form at pin 6 (plate) of V31A.

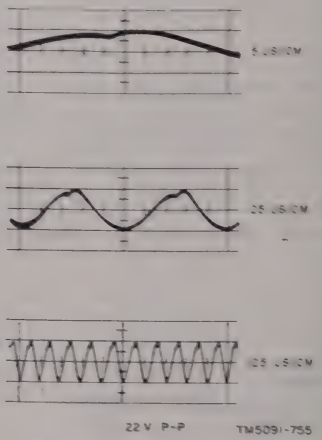


Figure 230. Wave form at J4.

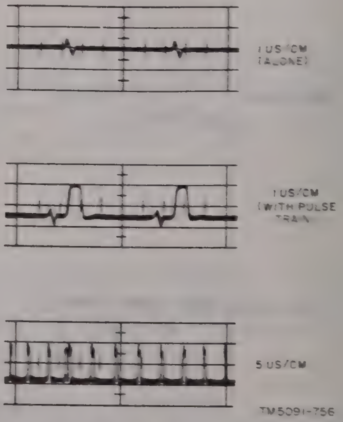
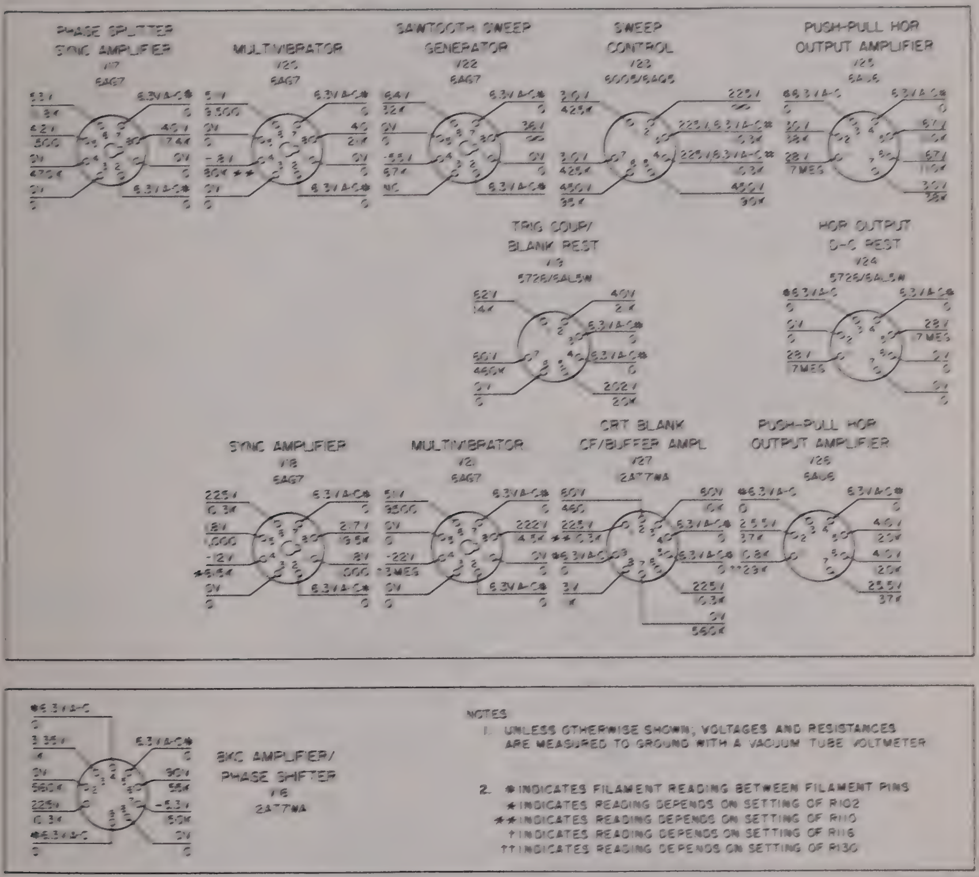


Figure 231. Crt display, time calibrator wave form.


PHASE SPLITTER SYNC AMPLIFIER
V17
6AG7
MULTIVIBRATOR
V20
6AG7
SAWTOOTH SWEEP GENERATOR
V22
6AG7
SWEEP CONTROL
V23
6005/6AQ5
PUSH-PULL HOR OUTPUT AMPLIFIER
V25
6AU6
TRIG COUP/ BLANK REST
V19
5726/6AL5W
HOR OUTPUT D-C REST
V24
5726/6AL5W
SYNC AMPLIFIER
V18
6AG7
MULTIVIBRATOR
V21
6AG7
CRT BLANK CF/BUFFER AMPL
V27
2AT7WA
PUSH-PULL HOR OUTPUT AMPLIFIER
V26
6AU6
3KC AMPLIFIER/ PHASE SHIFTER
V16
2AT7WA

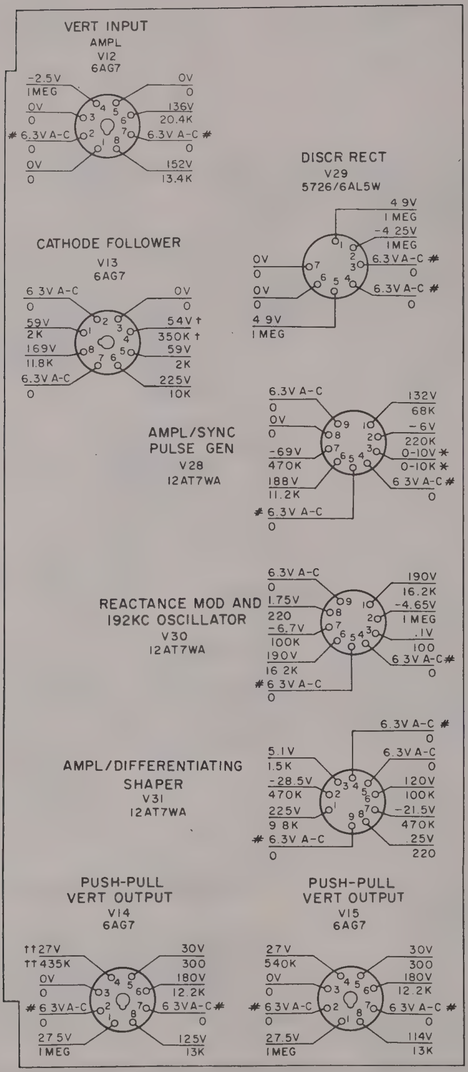
NOTES

1. UNLESS OTHERWISE SHOWN; VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A VACUUM TUBE VOLTMETER

2. ✱ INDICATES FILAMENT READING BETWEEN FILAMENT PINS
★ INDICATES READING DEPENDS ON SETTING OF R102
★★ INDICATES READING DEPENDS ON SETTING OF R110
† INDICATES READING DEPENDS ON SETTING OF R116
†† INDICATES READING DEPENDS ON SETTING OF R130

TM5091-757

Figure 232. Oscilloscope, bottom right section, tube socket voltage and resistance diagram.


VERT INPUT
AMPL
V12
6AG7
-2.5V
1MEG
0V
0
# 6.3V A-C
0
0V
0
0V
0
136V
20.4K
6.3V A-C #
0
152V
13.4K
DISCR RECT
V29
5726/6AL5W
4 9V
1 MEG
-4 25V
1MEG
6.3VA-C #
0
6.3V A-C #
0
0V
0
0V
0
4 9V
1MEG
CATHODE FOLLOWER
V13
6AG7
6 3V A-C
0
59V
2K
169V
11.8K
6.3V A-C
0
0V
0
54V †
350K †
59V
2K
225V
10K
AMPL/SYNC
PULSE GEN
V28
12AT7WA
6.3V A-C
0
0V
0
-69V
470K
188V
11.2K
# 6.3V A-C
0
132V
68K
-6V
220K
0-10V *
0-10K *
6 3V A-C #
0
REACTANCE MOD AND
192KC OSCILLATOR
V30
12AT7WA
6.3V A-C
0
1.75V
220
-6.7V
100K
190V
16 2K
# 6 3V A-C
0
190V
16.2K
-4.65V
1MEG
.1V
100
6 3V A-C #
0
AMPL/DIFFERENTIATING
SHAPER
V31
12AT7WA
5.1V
1.5K
-28.5V
470K
225V
9 8K
# 6.3V A-C
0
6.3V A-C #
0
6.3V A-C
0
120V
100K
-21.5V
470K
.25V
220
PUSH-PULL
VERT OUTPUT
V14
6AG7
†† 27V
†† 435K
0V
0
# 6 3VA-C
0
27 5V
1MEG
30V
300
180V
12.2K
6 3VA-C #
0
125V
13K
PUSH-PULL
VERT OUTPUT
V15
6AG7
27V
540K
0V
0
# 6 3VA-C
0
27.5V
1MEG
30V
300
180V
12 2K
6 3V A-C #
0
114V
13K

NOTES

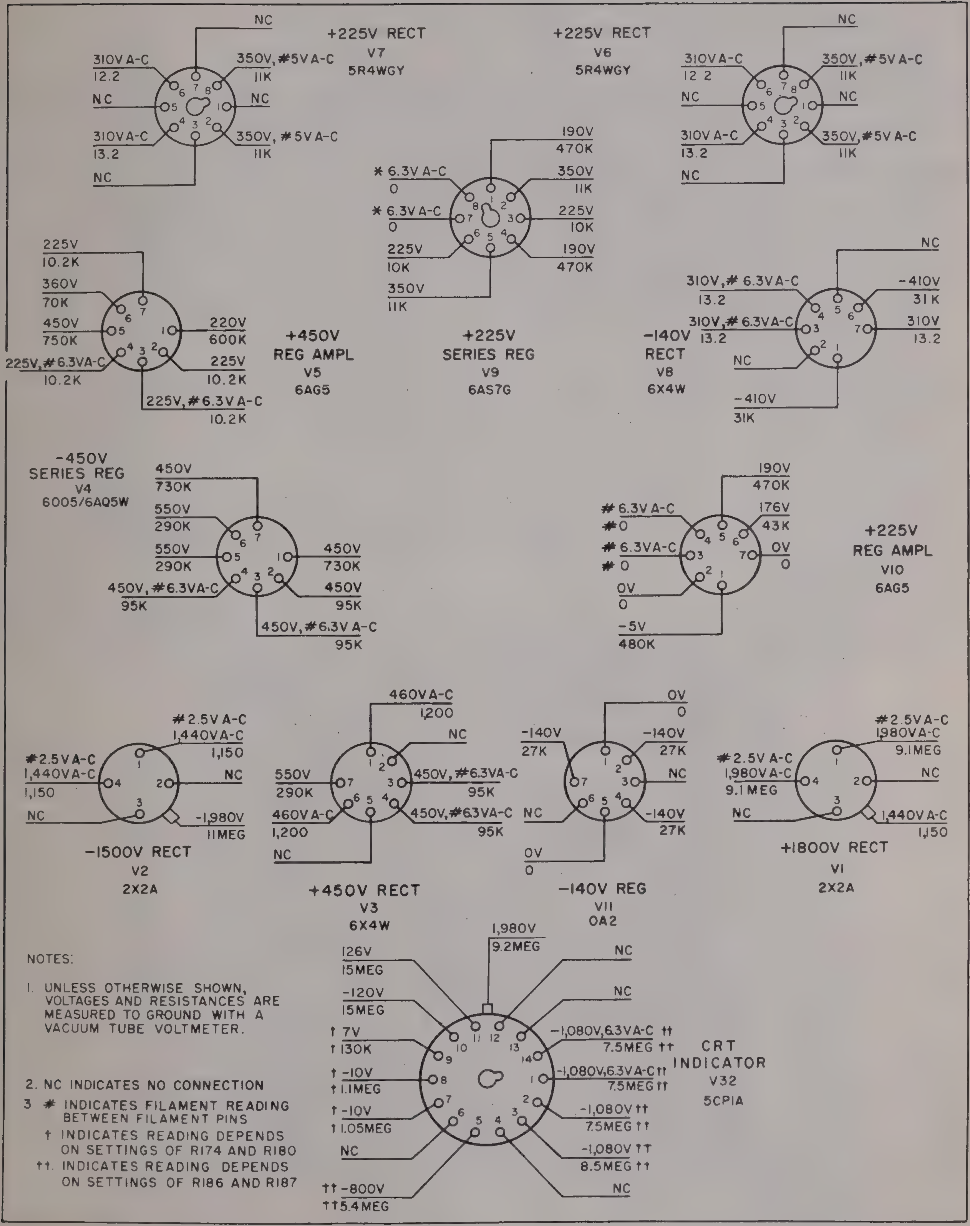
1 UNLESS OTHERWISE SHOWN VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A VACUUM TUBE VOLTMETER.

2 NC INDICATES NO CONNECTION

3 # INDICATES FILAMENT READING BETWEEN FILAMENT PINS
* INDICATES READING DEPENDS ON SETTING OF R150. VOLTAGE ALSO DEPENDS ON SYNC INPUT: WITHOUT SYNC, VOLTAGE 0-4V; WITH SYNC, VOLTAGE 0-10V.
† INDICATES READING DEPENDS ON SETTING OF R59
†† INDICATES READING DEPENDS ON SETTING OF R71

TM5091-758

Figure 233. Oscilloscope, bottom left section, tube socket voltage and resistance diagram.


+225V RECT
V7
5R4WGY
NC
310V A-C
12.2
350V, #5V A-C
11K
NC
NC
310V A-C
13.2
350V, #5V A-C
11K
NC
+225V RECT
V6
5R4WGY
NC
310V A-C
12 2
350V, #5V A-C
11K
NC
NC
310V A-C
13.2
350V, #5V A-C
11K
NC
190V
470K
* 6.3V A-C
0
350V
11K
* 6.3V A-C
0
225V
10K
225V
10K
190V
470K
350V
11K
+225V
SERIES REG
V9
6AS7G
225V
10.2K
360V
70K
450V
750K
220V
600K
225V, #6.3VA-C
10.2K
225V
10.2K
225V, #6.3V A-C
10.2K
+450V
REG AMPL
V5
6AG5
NC
310V, # 6.3VA-C
13.2
-410V
31K
310V, # 6.3VA-C
13.2
310V
13.2
NC
-410V
31K
-140V
RECT
V8
6X4W
-450V
SERIES REG
V4
6005/6AQ5W
450V
730K
550V
290K
550V
290K
450V
730K
450V, #6.3VA-C
95K
450V
95K
450V, #6.3V A-C
95K
190V
470K
# 6.3V A-C
# 0
176V
43K
# 6.3VA-C
# 0
0V
0
0V
0
-5V
480K
+225V
REG AMPL
V10
6AG5
#2.5V A-C
1,440VA-C
1,150
#2.5V A-C
1,440VA-C
1,150
NC
NC
-1,980V
11MEG
-1500V RECT
V2
2X2A
460VA-C
1,200
NC
550V
290K
450V, #6.3VA-C
95K
460V A-C
1,200
450V, #6.3VA-C
95K
NC
+450V RECT
V3
6X4W
0V
0
-140V
27K
-140V
27K
NC
NC
-140V
27K
0V
0
-140V REG
V11
0A2
#2.5V A-C
1980VA-C
9.1MEG
#2.5V A-C
1,980V A-C
9.1MEG
NC
NC
1,440V A-C
1,150
+1800V RECT
V1
2X2A
1,980V
9.2MEG
126V
15MEG
NC
-120V
15MEG
NC
† 7V
† 130K
-1,080V, 6.3VA-C ††
7.5MEG ††
† -10V
† 1.1MEG
-1,080V, 6.3VA-C ††
7.5MEG ††
† -10V
† 1.05MEG
-1,080V ††
7.5MEG ††
NC
-1,080V ††
8.5MEG ††
†† -800V
†† 5.4MEG
NC
CRT
INDICATOR
V32
5CP1A

NOTES:

1. UNLESS OTHERWISE SHOWN, VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A VACUUM TUBE VOLTMETER.

2. NC INDICATES NO CONNECTION

3 # INDICATES FILAMENT READING BETWEEN FILAMENT PINS

† INDICATES READING DEPENDS ON SETTINGS OF R174 AND R180

†† INDICATES READING DEPENDS ON SETTINGS OF R186 AND R187

TM5091-759

Figure 234. Oscilloscope, bottom center section, tube socket voltage and resistance diagram.

Section IX. TROUBLE-SHOOTING CONTROL MONITOR C–1151/TC

198. Control Monitor Trouble-shooting Data

The following data will assist maintenance personnel when trouble-shooting the control monitor.

Fig. No.	Description
268	Control Monitor C–1151/TC, over-all schematic diagram.
280	Control Monitor C–1151/TC, over-all wiring diagram.
235	Control monitor, top view.
236	Control monitor, side view.

199. Test Equipment Required for Control Monitor

The following test equipment is required fully to check the control monitor.

Item	Technical manual
Telephone EE–8–B	TM 11–333
Multimeter TS–352B/U	TM 11–5527A
Spectrum Analyzer TS–723/U	
Audio Oscillator TS–382A/U	TM 11–2684A
Oscilloscope OS–25/G	
Oscilloscope OS–8A/U	

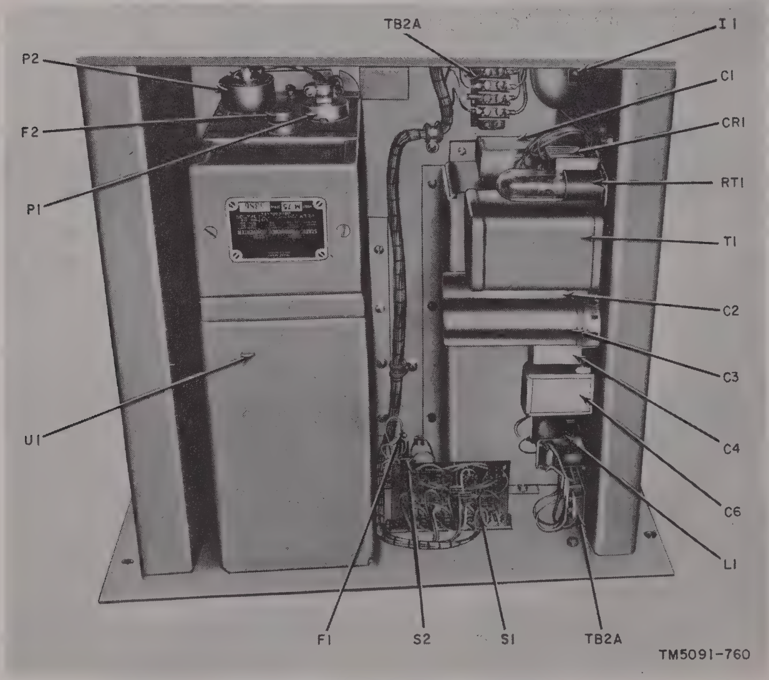


Figure 235. Control monitor, top view.

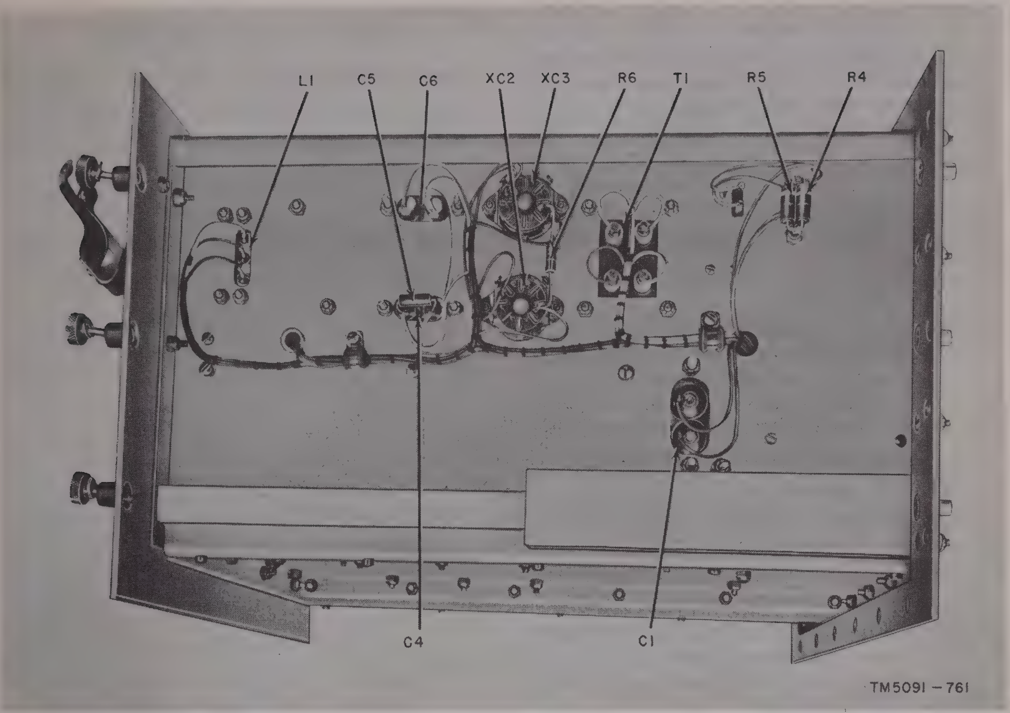


Figure 236. Control monitor, side view.

200. Control Monitor Trouble-shooting Procedure

The test panel is best serviced by taking voltage and resistance measurements. The most common source of trouble in the test panel is the microphone current supply to the telephone. Other sources of trouble are the push-button switches. The tests below may be made when trouble-shooting the control monitor. First, place a 115-volt a-c source across terminals C and D of J3.

a. Ringer Circuit.

(1) Measure the 20-cps ringing voltage across terminals E and F of J2 with the wave analyzer. There should be 100 volts ±10 per cent rms of 20-cps ringing voltage. This is the open-circuited voltage.

(2) Place a variable resistance of about 2,000 ohms across J2–E and J2–F. Slowly decrease this resistance until the output voltage drops to 75 volts rms. Measure the resistance and then determine the output power. It should be at least 7.5 watts. Temporarily short the output. Lamp RT1, which gives short-circuit protection, should begin to glow.

(3) The maximum 20-cps ringing voltage distortion should be 20 per cent. This should be checked with the wave analyzer at 60 cps and 120 cps in particular. Compare the values at 60 cps and 120 cps with the value at 20 cps and compute the percentage.

(4) The ringing voltage fundamental should be 20 cps ±20 per cent. This may be checked by Lissajous patterns

with the output of Audio Oscillator TS–382A/U connected to the horizontal input of the oscilloscope and the ringing voltage connected to the vertical input terminals. Adjust the frequency of the audio oscillator until a circle is seen on the oscilloscope; the frequency of the ringing voltage is equal to the value on the audio oscillator.

b. Telephone Circuit.

(1) Place the panel switch in the TEL SET position and connect field Telephone EE–8–B across terminals A and B of J2. Crank the ringing handle on the field telephone. This should ring the bell in the control monitor.

(2) Now place the field telephone across terminals C and D of J2. It should be possible to converse between the field telephone and the control monitor handset.

c. Panel Ring Switch. With the field telephone still connected across terminals C and D of J2, press the panel RING switch. The field telephone bell should ring.

d. Panel Selector Switch. Make a d-c check on the panel switch. Do this by using an ohmmeter and checking against the schematic diagram to be sure that terminals A, B, C, and D of J2 connect properly through the switch in all the switch positions. This testing can be performed readily by following the procedure below.

(1) *Order wire (J2–A and J2–B).*

Switch position	Check for continuity				Resistance (ohms)
	From		To		
	Jack	Terminal	Switch	Terminal	
REC	J2	A	S2	2 (TB1A–8)	100
SEND	J2	B	S2	5 (TB1A–6)	100
NORMAL					
TEL SET	J2	A	S2	2 (TB1A–8)	
	J2	B	S2	5 (TB1A–6)	

(2) *Test pair (J2–C and J2–D).*

Switch position	Check for continuity				Resistance (ohms)
	From		To		
	Jack	Terminal	Jack or Switch	Terminal	
REC	J2	C	J4	B	0
	J2	D	J4	A	0
SEND	J2	C	J1	B	0
	J2	D	J1	A	0
TEL SET	J2	C	S2	2 (TB1A–8)	0
	J2	D	S2	5 (TB1A–6)	0
NORMAL	J2	C	J2	D	620

201. Control Monitor Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the control monitor.

Symptom	Probable trouble	Correction
1. No 20-cps ringing voltage at pins C and D (test pair when test switch is in TEL SET and RING switch S2 depressed).	1. Faulty U1 (20-cps ringing generator). Faulty RING switch S2. Faulty test switch S1. No ac to ringing generator.	1. Replace U1. Replace S2. Replace S1. Check a-c input.
2. Order wire inoperative.	2. Faulty CR1. Faulty C2 and C3. Faulty T1. Faulty HS1 (handset). Faulty L1.	2. Replace CR1. Replace C2 and C3. Replace T1. Replace HS1. Replace L1.
3. Unable to modulate pulse out.	3. Faulty S1. Faulty test set.	3. Replace S1. Repair test set.
4. Unable to receive tone from demodulator.	4. Faulty S1. Faulty test set.	4. Replace S1. Replace test set.

Section X. TROUBLE-SHOOTING AUDIO TEST SET TS-762/TC

202. Audio Test Set Trouble-shooting Data

The following data will aid maintenance personnel in trouble-shooting the test set.

Fig. No.	Description
267	Audio Test Set TS-762/TC, schematic diagram.
282	Audio Test Set TS-762/TC, wiring diagram.
237	Audio test set, top view.
238	Audio test set, bottom view.
239	Audio test set, tube voltage and resistance diagram.

Note. Figure 239 shows the normal voltages as indicated by a vacuum tube voltmeter. The values given are typical for normal operation and may vary by ±10 per cent. The B+ supply voltage is +238 volts, +150 volts, and +14 volts. The diagram also shows the normal resistance between each tube socket terminal and the chassis ground as calculated. For long drift capacitive circuits, sufficient time was allowed for the readings to be stabilized.

203. Test Equipment Required for the Audio Test Set

The following test equipment is required to trouble-shoot the test set:

Item	Technical manual
Decade Resistance Box TS-679/U	TM 11-5520
Frequency Meter FR-67/U	TM 11-2698
Spectrum Analyzer TS-723/U	
Attenuator TS-402/U	
Test Set TS-140/PCM	TM 11-2096
Multimeter TS-352B/U	TM 11-5527A
Electronic Multimeter ME-6/U	TM 11-5549B
Double-pole double-throw switch	

204. Checking Audio Test Set Filament and B+ Circuits

Trouble within the unit may often be detected by checking the filament and high-voltage circuits before applying power to the equipment, and thus prevent damage to the power supply.

205. Audio Test Set Trouble-shooting Chart

The following chart will assist maintenance personnel in trouble-shooting the test set.

Symptom	Probable trouble	Correction
1. No 1,000-cycle tone.	1. Faulty T1. Faulty J1, J2, and/or J3. Open R27. Open R18. Failure to oscillate.	1. Replace T1. Replace. Replace R27. Replace R18. Check V1 and V2, voltages and resistances.
2. No reading on meter.	2. Faulty meter. Faulty diodes CR1 through CR4. Faulty S1. Faulty T2. Faulty J4, J5 or J6. Faulty Z1.	2. Replace meter. Replace. Replace S1. Replace T2. Replace. Replace Z1.
3. Incorrect or not able to calibrate both send and receive.	3. Faulty S1. Faulty R38. Faulty R40. Faulty M1.	3. Repair or replace S1. Replace R38. Replace R40. Replace M1.
4. Cannot measure distortion.	4. Faulty Z2. S1 faulty. M1 faulty. CR1 through CR4 faulty.	4. Replace Z2. Replace S1. Replace M1. Replace.

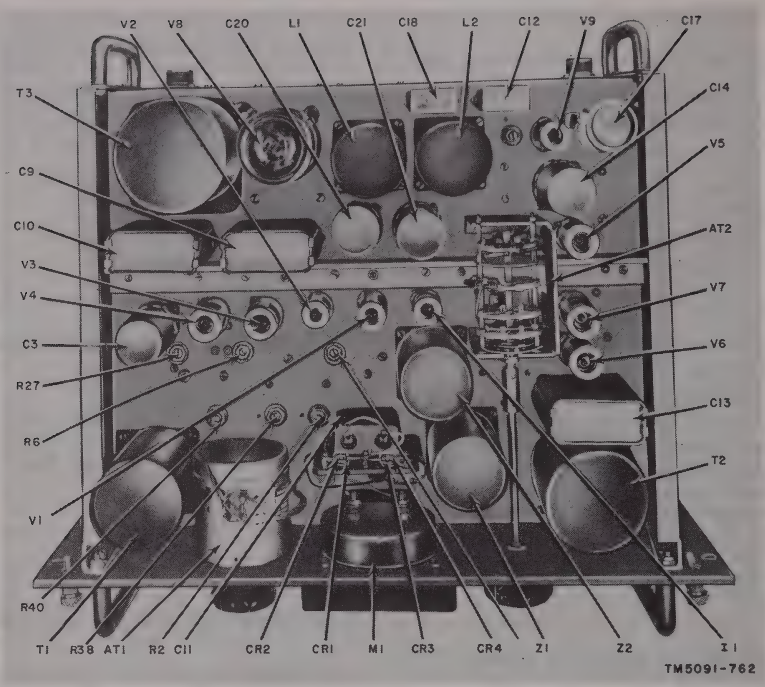


Figure 237. Audio test set, top view.

206. Adjustment of Internal Controls

Normally, these adjustments are set at the factory and need no readjustment. However, if the tests given in paragraph 207 indicate that these controls are not set properly, proceed according to the instructions given below.

a. FREQUENCY Potentiometer (R4A and R4B). Adjustment of potentiometer R4 varies the frequency of oscillator V1. The output frequency of the oscillator should be 1,000 cps ±3 cycles.

(1) Connect the audio test set to Frequency Meter FR–67/U (fig. 240), and turn on the equipment.

(2) Depress the MEASURE F1A button, on the front panel of the test set.

(3) Turn FREQUENCY control potentiometers R4A and R4B so that the frequency meter indicates 1,000 cps ±3 cps.

b. BRIDGE BALANCE Potentiometer R2.

(1) Connect the audio test set to the frequency meter as indicated in figure 240.

(2) Turn on the equipment.

(3) Depress the MEASURE F1A button on the audio test set.

(4) Adjust the FREQUENCY potentiometer to approximately 1,000 cycles.

(5) Turn off the equipment.

(6) With Multimeter TS–352/U, measure the resistance between the junction of R4A and R8 and the junction of R5 and C1. Record this reading.

(7) Transfer the multimeter leads to ground and pin 1 of V1.

(8) Adjust BRIDGE BALANCE potentiometer R2 so that the resistance

measured in subparagraph (7) above is the same as that recorded in subparagraph (6) above.

Caution: Always check the oscillator frequency after adjusting BRIDGE BALANCE potentiometer R2. The oscillator output frequency may have been disturbed.

c. DISTORTION Potentiometer R6 and OUTPUT BALANCE R27.

(1) Connect the equipment as indicated below and in figure 241.

(*a*) Connect a 600-ohm variable resistor to the SEND OUT binding posts of Audio Test Set TS–762/TC.

(*b*) Connect the center tap and the grounded end of the variable resistor to the AF INPUT binding posts of Spectrum Analyzer TS–723/U.

(*c*) Connect a vtvm (ME–22/PCM or equivalent) across the AF INPUT binding post of the spectrum analyzer.

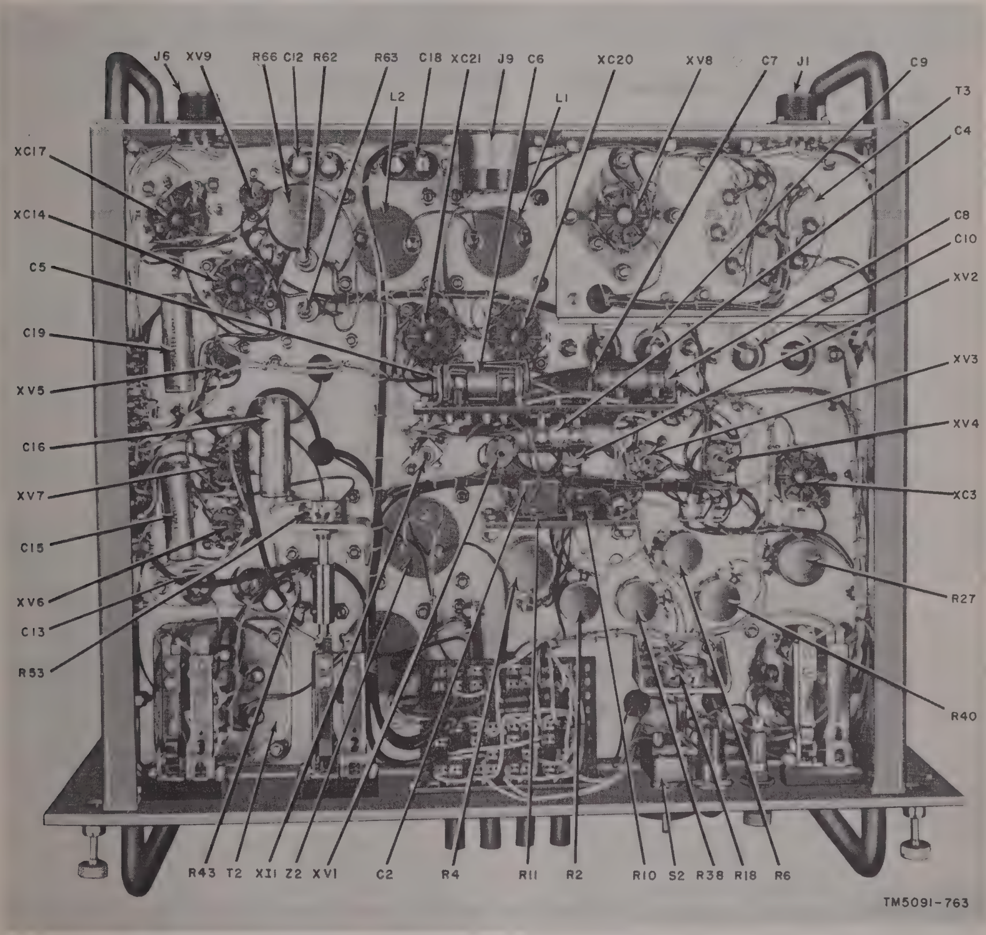
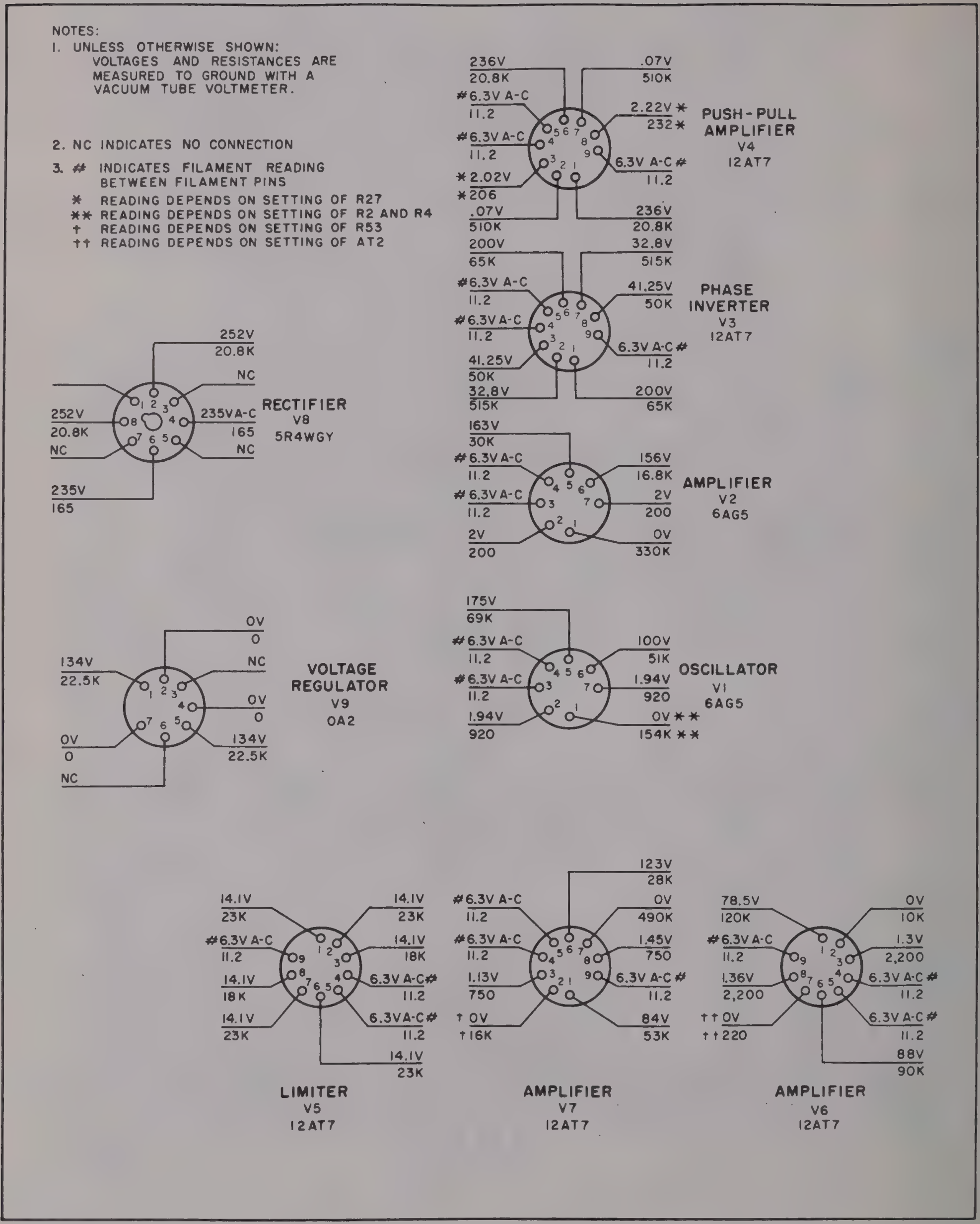

J6
XV9
R66
C12
R62
R63
C18
XC21
J9
C6
XC20
XV8
C7
J1
C9
L2
L1
T3
C4
XC17
XC14
C5
C19
XV5
C16
XV7
C15
XV6
C13
R53
C8
C10
XV2
XV3
XV4
XC3
R27
R40
R43
T2
XI1
Z2
XV1
C2
R4
R11
R2
R10
S2
R38
R18
R6
TM5091-763

Figure 238. Audio test set, bottom view.



NOTES:

1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A VACUUM TUBE VOLTMETER.
2. NC INDICATES NO CONNECTION
3. # INDICATES FILAMENT READING BETWEEN FILAMENT PINS

* READING DEPENDS ON SETTING OF R27
** READING DEPENDS ON SETTING OF R2 AND R4
† READING DEPENDS ON SETTING OF R53
†† READING DEPENDS ON SETTING OF AT2

PUSH-PULL AMPLIFIER V4 12AT7
236V 20.8K
.07V 510K
#6.3V A-C 11.2
2.22V * 232 *
#6.3V A-C 11.2
6.3V A-C # 11.2
* 2.02V * 206
.07V 510K
236V 20.8K
PHASE INVERTER V3 12AT7
200V 65K
32.8V 515K
#6.3V A-C 11.2
41.25V 50K
#6.3V A-C 11.2
6.3V A-C # 11.2
41.25V 50K
32.8V 515K
200V 65K
RECTIFIER V8 5R4WGY
252V 20.8K
NC
252V 20.8K
NC
235VA-C 165
NC
235V 165
AMPLIFIER V2 6AG5
163V 30K
#6.3V A-C 11.2
156V 16.8K
#6.3V A-C 11.2
2V 200
2V 200
0V 330K
VOLTAGE REGULATOR V9 0A2
0V 0
134V 22.5K
NC
0V 0
0V 0
134V 22.5K
NC
OSCILLATOR V1 6AG5
175V 69K
#6.3V A-C 11.2
100V 51K
#6.3V A-C 11.2
1.94V 920
1.94V 920
0V ** 154K **
LIMITER V5 12AT7
14.1V 23K
14.1V 23K
#6.3V A-C 11.2
14.1V 18K
14.1V 18K
6.3V A-C # 11.2
14.1V 23K
6.3V A-C # 11.2
14.1V 23K
AMPLIFIER V7 12AT7
123V 28K
#6.3V A-C 11.2
0V 490K
#6.3V A-C 11.2
1.45V 750
1.13V 750
6.3V A-C # 11.2
† 0V † 16K
84V 53K
AMPLIFIER V6 12AT7
78.5V 120K
0V 10K
#6.3V A-C 11.2
1.3V 2,200
1.36V 2,200
6.3V A-C # 11.2
†† 0V †† 220
6.3V A-C # 11.2
88V 90K
TM 5091-764

Figure 239. Audio test set, tube socket voltage and resistance diagram.

(2) Turn on the equipment.

(3) Press the MEASURE F1A button on the test set.

(4) Place the SEND DBM attenuator to +10.

(5) Use the ADJ SEND control (R18 of the audio test set) and set the output level of the TS–762/TC to approximately 10 dbm.

(6) Adjust OUTPUT BALANCE potentiometer R27 for lowest distortion output as read on the spectrum analyzer.

(7) Adjust the DISTORTION control, R6, until the level of distortion has reached the minimum value consistent with the requirements given in subparagraph (10) below.

(8) Repeat procedure given in subparagraph (6) above.

(9) Rotate ADJ SEND control R18 to its maximum clockwise position.

(10) Measure the total output; it should be at least +13 dbm.

(11) Set the output level of the test set to +10 dbm. Use the ADJ SEND control R18.

(12) The total distortion as read on the spectrum analyzer should not exceed 1 per cent.

d. HUM ADJ Potentiometer R66.

(1) Turn the Audio Test Set TS–762/TC to ON.

(2) Calibrate the RECEIVE and SEND sections.

(3) Terminate the SEND OUT and the RECEIVE IN terminals in 600-ohm resistance.

(4) Place SEND DBM attenuator AT1 in the +10 dbm position.

(5) Press the MEASURE F1A button.

(6) Rotate RECEIVE DBM attenuator AT2 until a readable indication is observed on the test set meter.

(7) Rotate HUM ADJ control R66 for minimum reading on the meter.

e. RECEIVE MTR ADJ R38.

(1) Connect Signal Generator SG–15/PCM to the RECEIVE IN binding posts of Audio Test Set TS–762/TC. The signal generator should be set for an output of 1,000 cycles at 2.45 volts.

(2) Turn on the equipment.

(3) Calibrate the test set receive section.

(4) Adjust the output of the test set to +10 dbm.

(5) Turn the RECEIVE DBM attenuator, AT2, to the +10 dbm position.

(6) Depress the MEASURE F1A button.

(7) Rotate the ADJ REC control, R53, until the meter pointer reaches the red line at the meter zero db position.

(8) Depress the CALIBRATE-REC button.

(9) Rotate the RECEIVE MTR ADJ, R38, until the meter pointer reaches the red line at the meter zero db position.

(10) Depress the MEASURE F1A button and make sure that the meter pointer is at the red line.

f. SEND MTR ADJ Potentiometer R40.

(1) Connect a 600-ohm resistor to the SEND OUT terminals of the audio test set, and connect a vtvm across the resistor.

(2) Turn on the test set.

(3) Calibrate the send section.

(4) Place the SEND DBM attenuator, AT1, to the +10 position.

(5) Adjust the output to a level of +10 dbm by pressing the MEASURE F1A button and using the SEND ADJ control, R18.

(6) Depress the MEASURE F1A button and rotate the ADJ SEND control, R18, for a reading of 2.45 volts on the vtvm.

(7) Press the CALIBRATE-SEND button and adjust the SEND MTR ADJ, R40, until the meter pointer reaches the red line at the meter zero db position.

(8) Depress the MEASURE F1A button and make sure that the output is still 2.45 volts.

207. Audio Test Set Tests

The following tests will be used as a reference and test procedure after major repairs.

a. Send Oscillator Frequency Range (Set).

(1) Connect the audio test set to the frequency meter as indicated in figure 240.

(2) Turn on the test set.

(3) Depress the MEASURE F1A button.

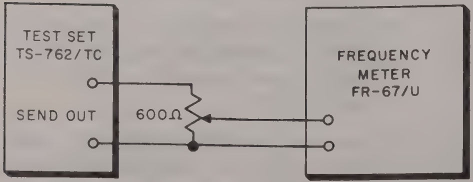
(4) Use the audio test set chassis FREQUENCY control R4 to adjust the frequency over the range of at least 970 to 1,030 cps. The frequency range should be continuous and the output amplitude should be relatively constant.

(5) After completing the above check, the frequency should be readjusted to 1,000 cps.

(6) Frequencies may be determined by reading Frequency Meter FR–67/U.

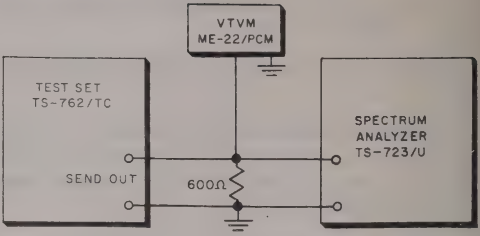
b. Send Oscillator Distortion Control (Set).

(1) Connect the equipment as indicated below and in figure 241.



TM5091-765

Figure 240. Send oscillator frequency range, test set-up.



TM5091-766

Figure 241. Send oscillator distortion control, test set-up.

(*a*) Connect a 600-ohm variable resistor to the SEND OUT binding posts of the audio test set.

(*b*) Connect the center tap and the grounded end of the resistor to the AF INPUT binding post of Spectrum Analyzer TS–723/U.

(*c*) Connect a vtvm (ME–22/PCM or equivalent) across AF INPUT binding posts of Spectrum Analyzer TS–723/U.

(2) Turn on the equipment.

(3) Press the test set MEASURE F1A button.

(4) Adjust the output level of the test set for +10 dbm.

(5) Measure the distortion with the wave analyzer at 1,000 cps, 2,000 cps, 3,000 cps, and 4,000 cps.

(6) Compute the distortion as follows:

$$D = \sqrt{D_1^2 + D_2^2 + D_3^2}$$

Where: D_1 = distortion reading at 2,000 cps

D_2 = distortion reading at 3,000 cps

D_3 = distortion reading at 4,000 cps

(7) The ratio of the distortion, D, to the distortion reading at 1,000 cps should be less than 1 per cent.

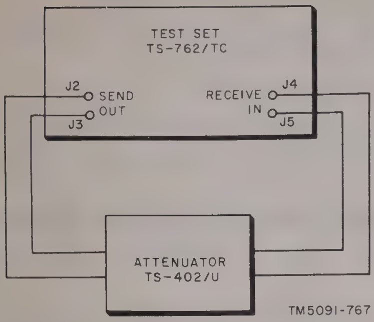

TEST SET
TS-762/TC
J2
SEND
OUT
J3
RECEIVE
IN
J4
J5
ATTENUATOR
TS-402/U
TM5091-767

Figure 242. Send attenuator calibration accuracy, test set-up.

c. Send Attenuator Calibration Accuracy (fig. 242).

(1) Connect the equipment as shown in figure 242.

(2) Turn on the test set.

(3) Calibrate the SEND section.

(4) Adjust the SEND DBM knob for +10 dbm.

(5) Insert 50 db of external attenuation.

(6) Set the RECEIVE DBM dial to –40.

(7) Depress the MEASURE F1A button.

(8) Use the REC ADJ knob, and set the meter pointer to the reference mark (red line).

(9) Reduce the SEND DBM attenuator by 1 db and add 1 db to the external attenuator.

(10) Any variation from the reference mark represents an error.

(11) Repeat the procedures given in subparagraphs (8) and (9) above for each step of the attenuator.

(12) Error should not exceed +.3 db per step and .6 db over-all.

d. Send Output Impedance at 1 Kc.

(1) Connect the equipment as shown in figure 243.

(2) Turn on the equipment.

(3) Depress the MEASURE F1A button to connect the internal oscillator section to the output jacks.

(4) Disable the internal oscillator by unscrewing the 3-watt bulb (I 1) to measure the output impedance alone.

(5) Switch from position 1 to position 2 while adjusting the resistance box until the meter indicates equal voltage for either switch position.

(6) The reading of the resistance box is equal to the output impedance of the test set.

(7) The impedance should be 600 ohms +10 per cent.

Caution: The output of SG–15/PCM must be kept below +10 dbm.

e. Send Output Balance to Ground.

(1) Connect the equipment as shown in figure 244.

(2) Turn on the equipment.

(3) Press the MEASURE F1A button and adjust the output for a level of +10 dbm. This value will give the poorest condition of output balance to ground.

(4) Read the voltage on the vtvm.

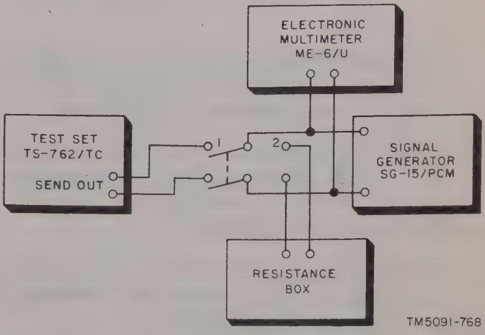

ELECTRONIC
MULTIMETER
ME-6/U
TEST SET
TS-762/TC
SEND OUT
1
2
SIGNAL
GENERATOR
SG-15/PCM
RESISTANCE
BOX
TM5091-768

Figure 243. Send output impedance at 1 kc, test set-up.

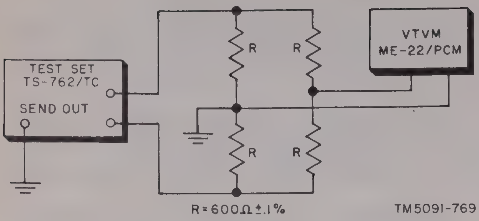


Figure 244. Send output balance to ground, test set-up.

(5) The meter reading indicates longitudinal unbalance and should not exceed 40 db down from +10 dbm. The vtvm reading should be 24 millivolts or less.

f. Receive Attenuator Accuracy.

(1) Connect the equipment as shown in figure 245.

(2) Turn on the equipment.

(3) Depress the MEASURE F1A button to connect the internal oscillator section to the output jacks.

(4) Adjust the oscillator for a level of +10 dbm.

(5) Insert 70 db of external attenuation with attenuator TS–402/U.

(6) Set the RECEIVE DBM dial to the –60 position (minimum attenuation).

(7) Use the REC ADJ knob, and set a convenient reference point (the red line).

(8) Rotate the RECEIVE DBM dial to the –50 position and decrease the external attenuation by 10 db.

(9) Any variation from the reference point determined in subparagraph (7) above represents a deviation from the standard.

(10) Repeat the procedure in subparagraph (8) above for all positions of the RECEIVE DBM dial.

(11) The error should not exceed +.3 db per step and +.6 db over-all.

g. Meter Calibration Accuracy.

(1) Connect the equipment as shown in figure 246.

(2) Turn on the test set.

(3) Calibrate the SEND section.

(4) Depress the MEASURE F1A button.

(5) Place the SEND DBM dial at +10.

(6) Place the RECEIVE DBM dial at +10.

(7) Set the meter to the zero position; use the REC ADJ control.

(8) Add 1 db of attenuation; use Attenuator TS–402/U.

(9) Note the reading on the meter scale.

(10) Repeat the procedure given in subparagraphs (8) and (9) above for the values of attenuation listed below:

Attenuation	Limit (db)
1	+ .15
2	+ .3
3	+ .5
4	+ .6
5	+ .8
7	+1.2
10	+1.5
20	+3.0

(11) The meter scale readings should be within the limits indicated above.

h. Receive Input Impedance at 1 Kc.

(1) Connect the equipment as shown in figure 247.

(2) Turn on the equipment.

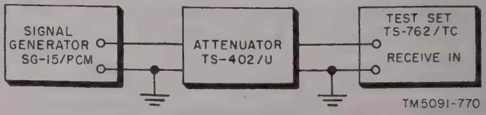


Figure 245. Receive attenuator accuracy, test set-up.

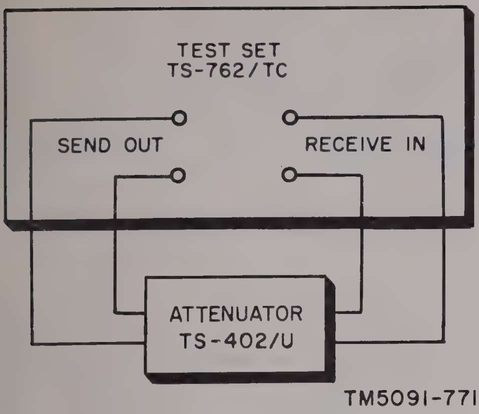


Figure 246. Meter calibration accuracy, test set-up.

(3) Press the MEASURE F1A button.

(4) Adjust the oscillator to +10 dbm, with the SEND DBM knob.

(5) Switch from position 1 to position 2 while adjusting the resistance box until equal voltage readings are indicated on the vtvm.

(6) The value of R as read from the resistance box is equal to the receive input impedance of the test set.

(7) The impedance should be 600 ohms +10 per cent.

i. Receive Input Balance to Ground.

(1) Connect the equipment as shown in figure 248.

(2) Turn on the equipment.

(3) Press the MEASURE F1A button.

(4) Adjust Signal Generator SG–15/PCM for an output of +10 dbm.

(5) Rotate the RECEIVE DBM dial until a readable indication is noted on the meter.

(6) The degree of receive longitudinal input unbalance is equal to the sum of the meter reading plus the RECEIVE DBM dial setting.

(7) Input unbalance should not exceed 40 db down from +10 dbm. The meter reading should be –30 dbm, or less.

j. F1A Network Response.

(1) Connect Signal Generator SG–15/PCM output binding posts to the RECEIVE IN binding posts of the test set.

(2) Turn on the equipment.

(3) Depress the MEASURE F1A button.

(4) Adjust Signal Generator SG–15/PCM for an output of approximately +10 dbm at 1 kc.

(5) Set the RECEIVE DBM dial to the +10 position.

(6) Use the REC ADJ control to set a convenient reference point (red line).

(7) Maintain the voltage from the signal generator at the level determined as instructed in subparagraph (4) above at vtvm ME–22/PCM, then impress the following frequencies:

Frequency	Attenuation db down	
	Maximum	Minimum
200	—24.0	—30
400	—7.5	—11.5
1,000	Reference	
3,000	—7.0	—13.0
5,000	—26 or greater	

(8) Read the values of attenuation on the test set meter. Use the RECEIVE DBM knob. Turn the knob until a readable value is obtained. The total value is the sum of the meter reading and knob setting.

(9) Response should be within the limits indicated.

k. F1A Noise Reading.

(1) Connect Random Noise Generator GR–1390A to the test set as shown in figure 250.

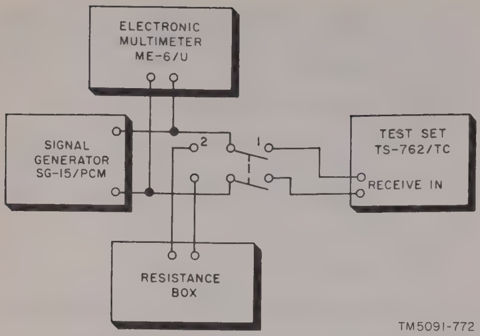

ELECTRONIC MULTIMETER ME-6/U
SIGNAL GENERATOR SG-15/PCM
2
1
TEST SET TS-762/TC
RECEIVE IN
RESISTANCE BOX
TM5091-772

Figure 247. Receive input impedance at 1 kc, test set-up.

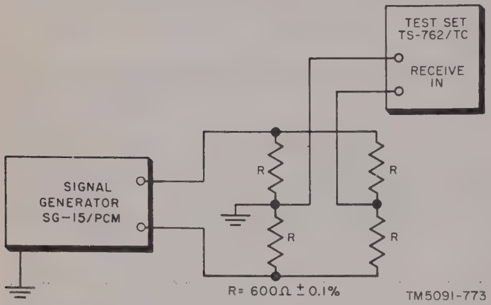

TEST SET TS-762/TC
RECEIVE IN
SIGNAL GENERATOR SG-15/PCM
R
R
R
R
R= 600Ω ± 0.1%
TM5091-773

Figure 248. Receive input balance to ground, test set-up.

(2) Turn the equipment on.

(3) Calibrate the SEND and RECEIVE sections.

(4) Press the MEASURE F1A button.

(5) Set the RECEIVE DBM dial to –10.

(6) Turn on Random Noise Generator GR–1390A, and allow it to warm up.

(7) Connect the 20-kc output of the generator to the test set RECEIVE jack and adjust the OUTPUT of noise generator for .6 volt on the vtvm.

Note. Be sure that the zero on the meter is accurately set.

(8) The test set reading and limits were determined by the readings obtained during the initial run on units that have F1A network response test. (For information only, a single test gave a total reading of –15 dbm.)

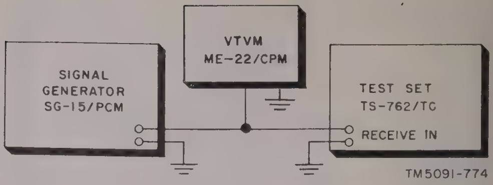

SIGNAL GENERATOR SG-15/PCM
VTVM ME-22/CPM
TEST SET TS-762/TC
RECEIVE IN
TM5091-774

Figure 249. F1A network response, test set-up.

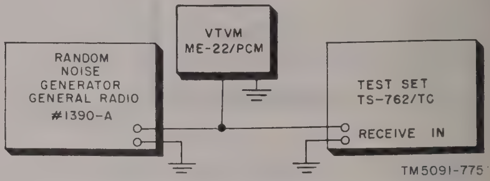

RANDOM NOISE GENERATOR GENERAL RADIO #1390-A
VTVM ME-22/PCM
TEST SET TS-762/TC
RECEIVE IN
TM5091-775

Figure 250. F1A noise reading, test set-up.

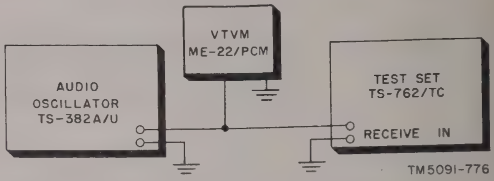

AUDIO OSCILLATOR TS-382A/U
VTVM ME-22/PCM
TEST SET TS-762/TC
RECEIVE IN
TM5091-776

Figure 251. Distortion network reading at 970 and 1,030 cycles, test set-up.

l. Distortion Network Reading at 970 and 1,030 Cycles.

(1) Connect the audio oscillator to the test set as shown in figure 251. Connect vtvm ME–22/PCM across the RECEIVE IN binding posts of the test set.

(2) Turn the equipment on.

(3) Press the MEASURE F1A button.

(4) Adjust the audio oscillator for an output of +10 dbm at 1 kc.

(5) Set the RECEIVE DBM dial to +10.

(6) Vary the REC ADJ knob until the meter reads zero.

(7) Push the DIST AT 1,000~button. Turn the RECEIVE DBM knob until a readable value is obtained. Total distortion is the sum of the meter reading and the RECEIVE DBM knob.

(8) Adjust the audio oscillator for the same voltage output as indicated in subparagraph (4) above at a frequency of 970 cps, and measure the distortion.

(9) Repeat the procedure given in subparagraph (8) above at a frequency of 1,030 cps.

(10) The distortion reading should be at least 40 dbm down at all three above frequencies.

Section XI. TROUBLE-SHOOTING VOLTAGE REGULATOR CN–236/G

208. Voltage Regulator Trouble-shooting Data

The following trouble-shooting data will assist maintenance personnel in trouble-shooting the voltage regulator.

Fig. No.	Description
270	Voltage Regulator CN–236/G, over-all schematic diagram.
285	Voltage Regulator CN–236/G, over-all wiring diagram.
252	Voltage regulator, top view showing rear of front panel.
253	Voltage regulator, bottom view.
254	Voltage regulator control unit, top view.
255	Voltage regulator control unit, bottom view.
256	Voltage regulator, tube socket voltage and resistance diagram.

209. Test Equipment Required for Voltage Regulator

The following test equipment is required:

a. Variac, 0 to 265 volts, 2 kva.

b. Two a-c voltmeters, 0 to 250 volts.

c. A-c ammeter, 0 to 20 amperes.

d. Variable load resistor, 0 to 50 ohms, 20 amperes.

210. Voltage Regulator Trouble-shooting Procedure

a. Tests to Be Made. The following tests may be used as a reference, and as a test procedure after major repairs.

(1) Output voltage with varying input voltage.

(2) Output voltage with varying load.

(3) Range of adjustment of output control.

(4) 230-volt operation.

b. Initial Connections. Connect the variac output terminals to input terminals E and D of AC POWER INPUT jack J4 of the regulator. Connect the a-c voltmeter across the same regulator input terminals. Connect the a-c ammeter and the variable resistor in series across the regulator output terminals (D and E of AC POWER OUTPUT jack J3). Connect an a-c voltmeter across the output terminals.

Caution: Be sure that all variable resistances are set for maximum resistance. Place the voltage regulator circuit breaker in 230-volt operation position.

211. Voltage Regulator Trouble-shooting Chart

The following chart is provided to assist maintenance personnel in trouble-shooting the voltage regulator.

Symptom	Probable trouble	Correction
1. No output voltage.	1. T4, X1-X2 winding open. T1 primary (1-2) shorted.	1. Replace T4. Remove short or replace T1.
2. No regulation either way.	2. Sensing element Z1 open. Output voltage control R11 open. C6 open or shorted. Powerstat brush open.	2. Replace Z1. Replace R11. Repair or replace C6. Repair or replace powerstat.
3. No regulation in one direction.	3. Relay K1 or K2 inoperative. Microswitch S1 or S2 open. R3 or R4 open.	3. Repair or replace K1 or K2. Repair or replace S1 or S2. Replace R3 or R4.
4. Output voltage too high. No regulation down or output voltage too low. No regulation up.	4. Sensing element shorted. R11 open at one end. Half of T2 secondary shorted.	4. Repair or replace. Repair or replace R11. Repair or replace T2.
5. No control of output voltage setting.	5. R11 variable arm shorted to either end of potentiometer.	5. Repair or replace R11.
6. Hunting.	6. SENSITIVITY control R12 set too high. R12 open. CR1 or CR2 open.	6. Reset correctly. Replace R12. Replace CR1 or CR2.

212. Voltage Regulator Tests

The following tests are included as test procedures to be used after major repairs.

a. Output Voltage with Varying Input Voltage (Full Load, 60 cps).

(1) Apply a source of 60 cps, 230 volts ac to the input to the variac and allow 30 seconds for warm-up.

(2) Adjust the variac so that there are 115 volts across the input to the regulator.

(3) Switch the regulator switch to 115-volt operation and adjust the variable resistor so that the ammeter reads 9 amperes.

(4) Increase the SENSITIVITY control until the regulator motor does not cease operating.

(5) Back off the SENSITIVITY control until the motor ceases to operate.

Note. The motor can be heard when it rotates.

(6) Adjust the output voltage control until the meter on the regulator output reads 115 volts.

(7) Adjust the variac so that the input voltage is 98 volts. The output voltage should be ±1 volt.

(8) Adjust the variac so that the input voltage is 132 volts. The output voltage should be ±1 volt.

b. Output Voltage with Varying Load (115 Volts ac, 60-cps Input). Vary the load resistor so that 17.4 amperes is drawn. The regulator output voltage should be 115 volts ±1 volt.

c. Range of Adjustment Output Control.

(1) Adjust the variac so that there are 115 volts into the regulator with a load of 9 amperes.

(2) Vary the output voltage from fully clockwise to fully counterclockwise. The output voltage should vary from 110 to 120 volts.

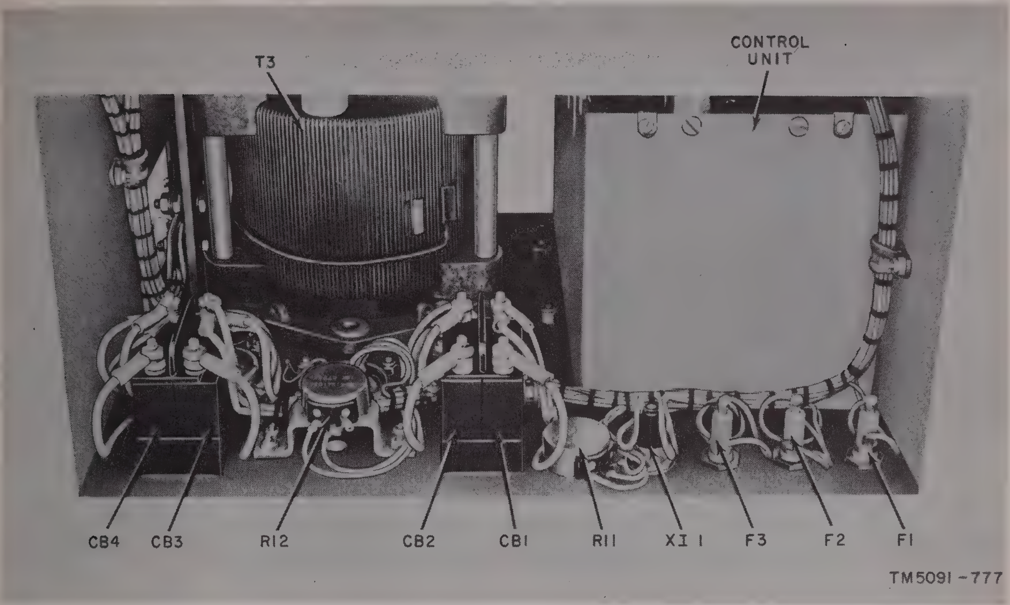

CONTROL UNIT
T3
CB4
CB3
R12
CB2
CB1
R11
XI 1
F3
F2
F1
TM5091-777

Figure 252. Voltage regulator, top view, showing rear of front panel.

(3) Return the output to 115 volts.

d. 230-volt Operation.

(1) Place the 230V AC POWER INPUT switch to ON. Adjust the variac so that 230 volts are applied to the regulator.

(2) Place a load of 9 amperes on the output. The output voltage should be 115 ±1 volt.

(3) Increase the input voltage to 264 volts. The output voltage should be 115 ±1 volt.

(4) Decrease the input voltage to 196 volts. The output voltage should be 115 ±1 volt.

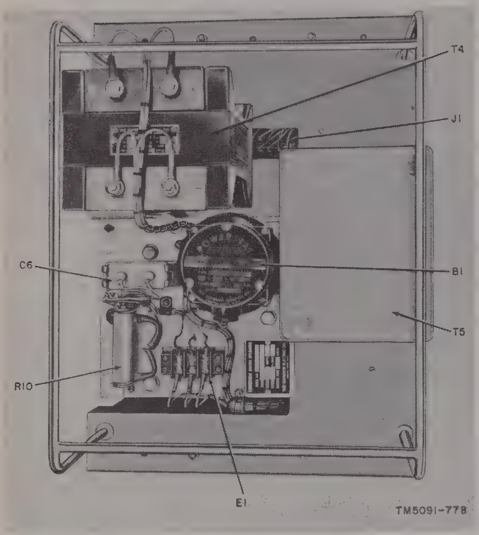

T4
J1
C6
B1
T5
R10
E1
TM5091-778

Figure 253. Voltage regulator, bottom view.

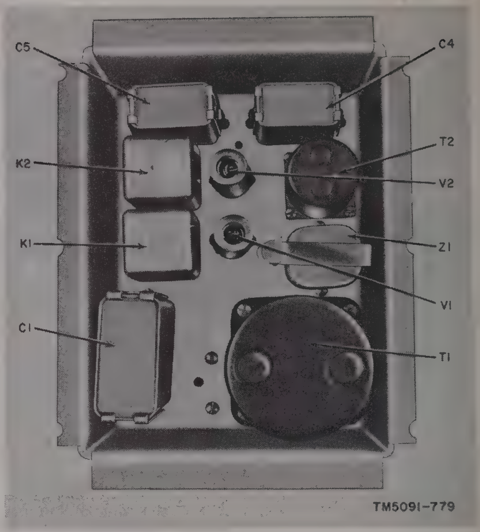

C5
C4
T2
K2
V2
K1
Z1
V1
C1
T1
TM5091-779

Figure 254. Voltage regulator control unit, top view.

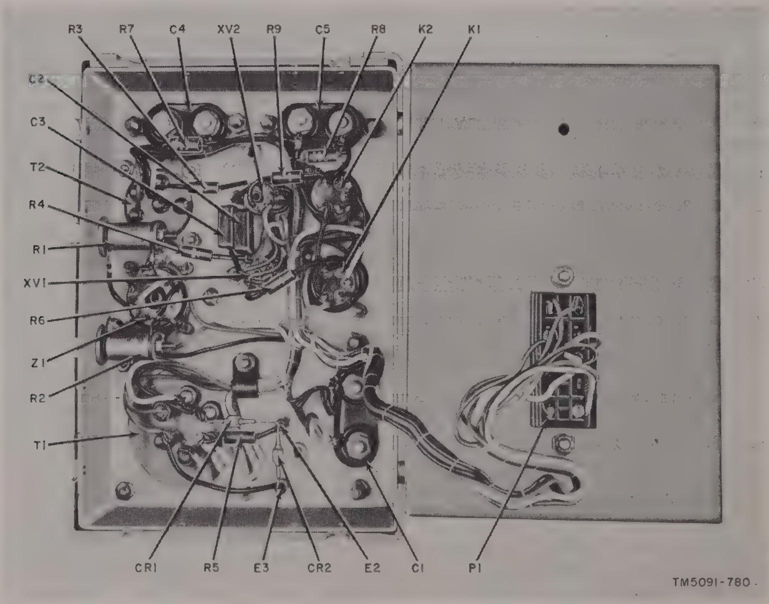
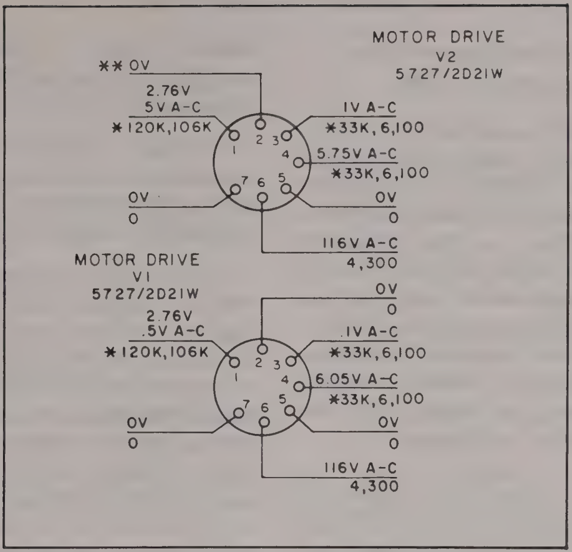

R3
R7
C4
XV2
R9
C5
R8
K2
K1
C2
C3
T2
R4
R1
XV1
R6
Z1
R2
T1
CR1
R5
E3
CR2
E2
C1
P1
TM5091-780

Figure 255. Voltage regulator control unit, bottom view.


MOTOR DRIVE
V2
5727/2D21W
** OV
2.76V
5V A-C
* 120K,106K
1
2
3
4
5
6
7
IV A-C
*33K, 6,100
5.75V A-C
*33K, 6,100
OV
0
OV
0
116V A-C
4,300
MOTOR DRIVE
VI
5727/2D21W
2.76V
.5V A-C
* 120K,106K
1
2
3
4
5
6
7
OV
0
.IV A-C
*33K, 6,100
6.05V A-C
*33K, 6,100
OV
0
OV
0
116V A-C
4,300

NOTES:

1. UNLESS OTHERWISE SHOWN VOLTAGES AND RESISTANCES ARE MEASURED FROM COMMON CATHODE WITH A VACUUM TUBE VOLTMETER.

2. * INDICATES READING WITH METER LEADS REVERSED
** 115 V A-C TO GROUND

TM5091-781

Figure 256. Voltage regulator, tube socket voltage and resistance diagram.

Section XII. REPAIRS

213. Replacement of Multiplexer Group Parts and Removal of Units

a. General. Most of the parts in the multiplexer group are readily accessible and can be replaced if found to be faulty. If the part requires replacement, carefully mark the wires connected to it with tags or other devices to avoid misconnection when the new part is installed. Follow this practice whenever replacement requires the disconnection of numerous wires. Where identification of capacitors or resistors is required, the capacitor and resistor color code charts (fig. 286 and 287) will provide the color code identification.

b. Video Restorer. The video restorer is mounted in a sliding drawer which pulls out from the front of the rack. All parts can be unsoldered and removed. All parts are readily available and no special precautions are necessary.

c. Modem. Each modem slides out from the mounting rack completely, and all parts are available.

d. Power Supply. The power supply must be removed from the rack by removing the screws that hold it in the rack, and pulling it out from the front. When it is out, all of the parts may be removed. An access door is also provided at the top front of the unit through which most of the smaller components may be reached. This is held closed by three captive screws (fig. 38). Fuses may be replaced from the front of the panel.

e. Multiplexer Subassembly. The multiplexer subassembly is removed by unscrewing the panel mounting screws, which hold it in the rack, and sliding it out. Wiring between the rack and the terminal boards on the subassembly must be removed. However, filters for the blower may be replaced by removing the filter panel held on with captive screws (fig. 34). Some of the smaller parts also may be reached through this panel. Major repairs or overhaul necessitates removal of the complete subassembly from the rack.

f. Voltage Regulator. The voltage regulator is removed by unscrewing the panel mounting screws. The cover over the control amplifier also must be removed to permit servicing.

g. Oscilloscope. All parts in the oscilloscope, with the exception of those mounted on the rear of the front panel, are accessible after the unit is removed from the rack. The front panel must be removed to service those units behind the panel. This can be done after removing knobs and mounting nuts on the various switches and the crt mask and four screws that hold the crt shield. The switches remain on the chassis, while all other components remain on the panel. All parts are then available for removal.

h. Control Monitor. The control monitor is mounted on slides and may be pulled forward in the rack. When this is done, all parts are available for removal.

i. Audio Test Set. The test set may be removed from the rack by removing the screws that hold it in place. When this is done, all parts are available for inspection, testing, or replacement.

Note. Disconnect the cables before pulling the unit forward.

j. Delay Line. The delay line is available from the rear of the rack. The delay line is serviced only in extremely rare cases, and then in a place where it may be completely disassembled.

214. Refinishing

Instructions for refinishing badly marred panels on exterior cabinets are contained in TM 9-2851, Painting Instructions For Field Use. Refer to these instructions when necessary.

Section XIII. ALIGNMENT, ADJUSTMENT, AND FINAL TESTING

215. Reference Data

The following reference may assist maintenance personnel during alignment, adjustment and final testing.

Fig. No.	Description
258	Multiplexer rack, over-all schematic diagram.
273	Multiplexer rack, over-all wiring diagram.

216. Test Equipment Required

The following test equipment is required for alignment, adjustment, and final testing:

a. Four Multiplexer Sets AN/TCC–13 (terminals which have been checked and can be used as test equipment).

b. One Electronic Multimeter TS–505/U.

c. Three Field Telephones EE–8–B.

d. One Multimeter TS–352/U.

217. Tests Required

a. 23-channel Operation.

(1) Fan rotation.

(2) Filament voltage.

(3) B+ voltage.

(4) Power consumption.

(5) Pulse form restorer wave forms.

(6) Ppm wave forms.

(7) Blanking gate alignment.

(8) Pwm test point wave form.

(9) DEMTPX delay line integration.

(10) MTPX delay line integration.

(11) Pulse train alignment.

(12) Switching circuits.

(13) Impedance of party-line terminals.

(14) Telephone circuit and order-wire circuits.

(15) Ringing circuit.

(16) Remote keying circuits.

(17) Audio levels.

(18) Alarm circuit.

(19) Signal-to-noise ratio.

(20) Channel cross talk.

b. 45-channel Operation.

(1) Symmetry control.

(2) Channel cross talk.

(3) Channel signal-to-noise ratio.

218. Test Procedure

It is assumed that all components have been tested separately and that they have been interconnected to form a complete terminal. Align and check the complete terminal by connecting the terminal to be tested back to back with a test terminal, with all modems set for four-wire operation and the remote keying units in the normal position.

a. Preliminary Adjustments. Connect the AN/TCA–1 to the two AN/TCC–13 terminals. Switch on the power to the two terminals. Align the output pulse train of each terminal and set the output pulse train amplitude of each to .5 volt from base line to peak. The pulse width should be a maximum of .8 usec at 50 per cent amplitude. Set the 23 CHAN-45 CHAN switch on the video restorer to the 23 CHAN position and the P.T. OUT AMPL switch to the LOW position. Whenever an alignment or integration of the delay lines is to be made, the AN/TCA–1 should be checked for any obvious defects which could throw the alignment or integration off.

Note. When observing a wave form in a video restorer, be sure the oscilloscope is being synchronized from the associated video sync jack.

b. Fan Rotation. Turn on the power supply FILAMENT switch of the AN/TCA–1. The fan in the video restorer should start turning immediately. If it does not, quickly throw the FILAMENT switch to off. The fan should be rotating in the direction that sucks air into the front and out of the rear of the video restorer.

c. Filament Voltage. With a vtvm measure the filament voltage between E51 and E52 (ground) in both video restorers. It should be 6.3 +.4 volts.

d. B+ Voltage. Switch on the power supply +250V circuit breaker of the AN/TCA–1. With a vtvm, measure the B+ voltage at the B+ fuse of both video restorers on the reshaper side of the fuse. It should be 250 ±10 volts. When B+ has been turned on, the video restorer ALARM light on both reshapers should go out.

e. Power Consumption. Switch the power supply ±250V and the FILAMENT circuit breakers to OFF. Connect the AN/TCA–1 to the a-c source through Multimeter TS–352/U. The power taken by the AN/TCA–1 with Oscilloscope OS–25/G and Audio Test Set TS–762/TC off should not be greater than 775 watts and not less than 725 watts (at 115 volts ac). The oscilloscope should take no more than 300 ±25 watts at 115 volts ac. The test set should take no more than 40 ±10 watts at 115 volts ac.

f. Pulse Form Restorer Wave Forms. The wave forms available at the front panel of the video restorer should be observed on the oscilloscope and should not vary by more than 20 per cent in width and amplitude from the figures listed, except as indicated.

Test point	Description	Fig. ref	Note
E1	INPUT FROM EASTFACING REC INPUT FROM WESTFACING REC	59	.5 v p-p, .8 usec max at 50 per cent amplitude.
E5	DEMTPX GATE (eastgoing) DEMTPX GATE (westgoing)	61	125 to 155 v p-p, 3.8 to 4.3 usec at 50 per cent amplitude.
E4	Blanking GATE (eastgoing) Blanking GATE (westgoing)	62	34 to 55 v p-p, 8-12 v p-p pulses, 4.3 ±1.2 usec at 50 per cent amplitude.
E6	MTPX GATE (eastgoing) MTPX GATE (westgoing)	63	102 to 112 v p-p, 8 ±1 usec at 50 per cent amplitude.
E3	MODEM CHAN PULSES (eastgoing) MODEM CHAN PULSES (westgoing)	64	3.5 to 7.5 v p-p, .2 to .4 usec at 50 per cent amplitude.
E2	OUTPUT TO EASTFACING XMTR OUTPUT TO WESTFACING XMTR	60	Set SYM ADJ to .25 volt base line to peak, .48 to .58 usec at 50 per cent amplitude.

g. PPM Test Point Wave Forms. The PPM test point wave form should be measured at each modem. It should not vary by more than 20 per cent in width and amplitude from that shown in figure 88.

h. Blanking Gate Alignment. The following procedure should be followed to align the blanking gates at both video restorers.

Note. Be sure that there are no obvious defects which might throw the alignment off.

(1) Have all modems plugged in.

(2) Have all remote keying units in NORMAL POSITION.

(3) Place all D&I-THRU switches in D&I position.

(4) Observe the DEMTPX GATE and MTPX GATE at test points E5 and E6 on the oscilloscope. The DEMTPX GATE should be 125 to 155 volts and 3.8 to 4.3 usec at the 50 per cent amplitude point. The MTPX GATE should be 102 to 112 volts in amplitude and 8 ±1 usec wide at 50 per cent amplitude.

(5) Place channel 1 in D&I and the remaining channels in the THRU position.

Note. The D&I-THRU plugs and the associated video restorer are on the same side of the rack. Observe the wave form at pin 7 of V13. The amplitude should be between 6.8 and 8.5 volts peak to peak. Repeat the procedure above with channel 2 in the D&I position and all others in the THRU position. Repeat the procedure above until all eight channels have been measured individually.

(6) When all the blanking gates at pin 7 of V13 are the proper amplitude, the blanking gate timing may be aligned, as follows:

(*a*) Align the incoming pulse train at the terminal.

(*b*) Observe the blanking gates at BLANKING GATE test point E4.

(*c*) Place channel 1 in the D&I position, channel 2 in the THRU position, and the remainder in the D&I position.

(*d*) Center the channel 1 blanking gate on the scope face. Then place channel 1 in the THRU position. The channel 1 pulse of the incoming pulse train will be seen. Record the time in usec from the center of channel 1 pulse to the 50 per cent amplitude point of the leading and trailing edges (two readings) of the channel 1 blanking gate. (The leading edge of the blanking gate should occur before the channel pulse.) If there is a difference between the two readings of greater than 1 usec, then move the lead on the DEMTPX delay line connecting the blanking pulse to channel 1 so that the *difference* is 1 usec or less.

Note. The associated video restorer and the DEMTPX delay line are on the same side.

(7) Place channel 2 in the D&I position, channels 1 and 3 in the THRU position, and the remainder in the D&I position. Repeat the same measurement as described in subparagraph (6) (*d*) above.

(8) Repeat the procedure above for all eight channels. In each case, leave the two channels adjacent to the one under test in the THRU position, and all others in the D&I position. When doing channel 8, only channel 7 need be in the THRU position.

(9) When properly aligned, all blanking gates should be between 3.1 and 5.5 usec at 50 per cent amplitude and the amplitudes may vary from 28 to 55 volts peak to peak.

i. Pwm Test Point Wave Forms. The pwm wave form should be measured on each modem. It should not vary more than 20 per cent in amplitude from that shown in figure 92. The pwm wave form widths will be variable until the demodulator delay line is integrated properly.

j. DEMTPX Delay Line Integration. The following procedure should be followed to integrate the DEMTPX lines:

Note. The associated modem, demodulator delay line, and video restorer for this test are on the same side of the rack.

(1) Be sure the incoming pulse train is at the terminal.

(2) Place all D&I-THRU plugs in D&I position and the remote keying units in NORMAL POSITION.

(3) Observe the DEMTPX GATE at E5. It should be 125 to 155 volts and 4.0 ±.5 usec at 50 per cent amplitude.

(4) Observe the sawtooth input to the demodulator on each channel (on the back of the delay line).

(5) Observe each modem pwm test point and adjust each respective trimmer on the demodulator delay line until each pwm wave form is 1.8 ±.8 usec across the flattop (fig. 92). If the tolerance given above cannot be obtained with the trimmer, the lead that connects the delay line to the integrating network on the side of the line should be moved. If the pwm pulse is too narrow, the lead should be moved up the delay line, and if the pwm pulse is too wide the lead should be moved

down the line. Moving this lead one tap will cause a change of 1 microsecond in the pwm pulse.

k. MTPX Delay Line Integration. The following procedure should be followed to integrate the two MTPX delay lines.

Note. For this procedure the associated video restorer and MTPX delay line are on the same side but the modem is on the opposite side.

(1) Place all D&I-THRU plugs in the D&I position.

(2) Place the remote keying units in NORMAL OPERATION position.

(3) Observe the inserted channel pulse at the MODEM CHAN PULSES test point, E3. These should be eight channel pulses, and they may vary from 3.5 to 7.5 volts peak to peak.

(4) Observe the pulse train at the OUTPUT TO WESTFACING (EASTFACING) XMTR test point E2. The inserted pulses, channels 1 through 8, should appear in the pulse train. To be sure that channels 1 through 8 are the inserted pulses and not the terminal pulses, vary the PULSE POSITION control of each modem. The respective channel pulse should move.

Note. The associated modems and video restorer are on opposite sides for this test.

(5) Now observe the MTPX GATE on the same video restorer as the output pulse train was observed in subparagraph (4) above. It should be 102 to 112 volts in amplitude and 8 ±1 usec wide at the 50 per cent amplitude point.

(6) Set the oscilloscope so that 2 cm (two boxes) are equal to 20 volts in amplitude.

(7) Observe the sawtooth input to each modem on the oscilloscope (on the back of the MTPX delay line).

(8) Adjust the respective capacitor trimmers on the MTPX delay line until each sawtooth is 20 ±2 volts in amplitude (that is, two boxes on the oscilloscope).

(9) Observe the pulse train at the OUTPUT TO EASTFACING (WESTFACING) XMTR test point E2 and align channels 1 through 8. This is done as follows:

   (*a*) Adjust the sweep speed so that there is one complete pulse train across 10 cm of the scope face (that is, 2 marker pulses and 23 channel pulses).

   (*b*) Switch on the timing pips and adjust the TIMING PIP PHASE control until the leading edge of the second marker pulse is aligned with a timing pip.

   (*c*) Adjust the PULSE POSITION control of each modem until the respective channel pulse is aligned with the leading edge of its respective timing pip.

(10) Use the timing pips (5.2 usec apart) and adjust the scope sweep so that 1 cm equals 1 usec (that is, 1 usec per centimeter).

(11) Observe each modulator sawtooth on the scope and adjust the vertical gain for a deflection of 2 centimeters. With the SWEEP PHASE control, move the sawtooth so that the center of the leading edge crosses the center of the graticule of the oscilloscope.

(12) Without touching the SWEEP PHASE control, observe the respective channel pulse at the MODEM CHAN PULSES test point, E3. Adjust the VERTICAL GAIN until a channel pulse can be readily seen. The point where the channel pulse leading edge leaves the base line should fall within .5 usec before or .8 usec later than the center of the sawtooth slope. If the pulse does not fall within the above specification, proceed to subparagraph (13) below. If it does, consider that channel completed.

(13) If the pulse occurs sooner than .5 usec with respect to the sawtooth center, the lead from the delay line to the inte-

grating circuit should be moved up the line. If the pulse occurs later than .8 usec, the lead should be moved down the line. One tap will move the sawtooth 1 usec.

Note. If a lead has been moved as above, repeat the instructions outlined in subparagraphs (9) through (13) above.

l. Pulse Train Alignment. Align the output pulse train as directed in subparagraph *k*(9) above.

m. Switching Functions. Since both directions of the AN/TCA–1 are similar in operation, this procedure may be used to check both directions. The switching functions should be checked as follows:

(1) Place the D&I-THRU switches in the D&I position, 2W-4W switches in the 4W position, and the PARTY LINE-PRIV switches in the PRIV position.

(2) Turn on the test set and allow it to warm up.

(3) Calibrate the test set (par. 55).

(4) Set the SEND DBM for –4 dbm output and RECEIVE DBM for 0 dbm.

(5) Adjust the sweep speed on the oscilloscope for 1 usec per cm.

(6) Observe the OUTPUT TO EASTFACING (WESTFACING) XMTR test point E2 with the oscilloscope.

(7) Place the control monitor panel switch in the SEND position.

(8) Turn each modem selector switch to SR, one at a time, and observe on the scope that each channel pulse is modulating approximately ±.5 usec.

(9) Connect an adapter from the 4W REC terminals to the audio test set REC jacks and place the modem selector switch in SL position. The test set should read –4 dbm (same as it is sending out), and the channel pulse that is associated with the 4W REC terminals should not be modulated. Each channel in both directions should be tested similarly.

(10) Modulate the channel pulses from one of the test terminals, one at a time, with a –4 dbm input (subpar. (1) through (8) above. Place the control monitor switch on the AN/TCA–1 in REC position. Turn the modem selector switch of each respective channel in the AN/TCA–1 being tested to RR and adjust the AUDIO OUTPUT GAIN control on the modem until the audio test set reads zero dbm output. The same procedure applies for the other test terminal and its associated modems.

(11) Connect an adapter from the 4W SEND terminals to the audio test set SEND jacks and place the modem selector switch in RL position. The test set should read –4 dbm and the channel pulse associated with the 4W SEND terminals should not be modulated.

n. Impedance of Party-line Terminals.

(1) Place the 2W-4W switches in 4W on channels 1 and 2 (both directions).

(2) Turn the OUTPUT AUDIO GAIN control fully counterclockwise on channels 1 and 2 modems (both directions).

(3) Place the PARTY LINE-PRIV switches in PARTY LINE operation.

(4) Connect the test equipment as shown in figure 257.

(5) Connect channel 1 PARTY LINE terminals E9 and E10 to the test equipment.

(6) Set the decade box to 300 ohms.

(7) Adjust the audio oscillator to 1,000 cps and its output for a .2-volt a-c reading on the vtvm with the switch in position 1.

(8) Adjust the decade box so that the vtvm reads the same in switch positions 1 and 2.

(9) Record the decade box reading. The reading should be 320 to 400 ohms.

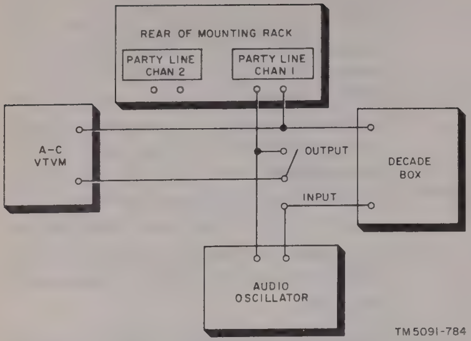


Figure 257. Impedance of party-line terminals, test set-up.

(10) Disconnect the input terminals from channel 1 PARTY LINE terminals and connect them to channel 2 PARTY LINE terminals.

(11) Repeat the procedures in subparagraphs (1) through (9) above for channel 2.

(12) Disconnect the test equipment.

o. Telephone Circuits and Order-wire Circuits. The telephone circuit should be checked as follows:

(1) Place the control monitor switches S1 of both east and west terminals and the AN/TCA–1 being tested in NORMAL position.

(2) Place channel 1 of both terminals in 2W operation.

(3) Place the D&I-THRU switch in D&I, the PARTY LINE-PRIV switch in PARTY LINE, the 2W-4W switch in 4W, and the remote keying units in NORMAL OPERATION positions.

(4) Press the RING switch at each terminal separately. The bell at both terminals and at the AN/TCA–1 should ring.

(5) Press the RING switch at the AN/TCA–1. Its own bell and the bell at each terminal should ring.

(6) It should be possible to converse between terminal and terminal, and between either terminal and the AN/TCA–1 over channel 1 by using the handset provided with the control monitor.

(7) Place channels 3 through 8 of both terminals and the AN/TCA–1 in two-wire operation. Place the control monitor switches S1 of both terminals and the AN/TCA–1 in TEL SET position.

(8) Place the east terminal modem selector switch in either the RR or SR position. Place the eastfacing modem selector switch at the AN/TCA–1 in either the SR or RR position. By using the handset, it should be possible to converse between the east terminal and AN/TCA–1, but not the west terminal. Do each channel 3 through 8 individually.

(9) Repeat the procedures in subparagraphs (7) and (8) above for the west terminal modems and the west-facing modem at the AN/TCA–1.

(10) Return channels 1 through 8 of both terminals and the AN/TCA–1 to four-wire operation, and push all control monitor NORMAL switches.

p. Ringing Circuits.

(1) *Private-line connection.*

(*a*) Place all remote keying units in NORMAL OPERATION position.

(*b*) Place all D&I-THRU switches in D&I position.

(*c*) Place all PARTY LINE-PRIV switches in PRIV position.

(*d*) Place all the 4W-2W modem switches in the AN/TCA–1 and both AN/TCC–13 terminals in the 2W position.

(*e*) By using field Telephone EE–8–B, it should be possible to ring *between* the following modem two-wire lines of each channel:

Terminal	Repeater
West terminal modem channels	Westfacing modem channels
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
East terminal modem channels	Eastfacing modem channels
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8

(2) *Party-line connection.*

(*a*) Place all 4W-2W modem switches at the AN/TCA-1 in 4W position.

(*b*) Place all PARTY LINE-PRIV switches in PARTY LINE position.

(*c*) Place an EE-8-B on the party-line connection of mounting rack terminals E9 and E10.

(*d*) Ringing at the repeater local line should ring the corresponding channel at *both* terminals.

(*e*) Ringing at a terminal should cause ringing at the repeater local line and also at the far terminal.

(*f*) Repeat the procedures in subparagraphs (*a*) through (*e*) above for channel 2; use party-line terminals E141 and E142.

q. Remote Keying Circuits. Both remote keying circuits should be checked as follows:

(1) Place channels 1 and 2 of the repeater and both terminals in remote keying operation. At the repeater, all channels should still be D&I and PARTY LINE connection.

(*a*) There should be no channels 1 and 2 pulses arriving at the repeater from the terminals. This can be checked at the INPUT FROM EASTFACING (WESTFACING) REC test point E1 of both video restorers.

(*b*) There should be no ringing at the repeater. This can be checked by placing a field telephone on the local PARTY LINE terminals of both channels.

(*c*) There should be no repeater inserted pulses. This can be checked at MODEM CHAN PULSES test point E3 of both video restorers.

(*d*) There should be an open circuit across E1 and E2 and also across E11 and E12 on the mounting rack.

(2) At the repeater, place a short circuit across E13 and E14.

Caution: There are approximately 40 volts dc on these terminals.

(*a*) This should insert channel 1 in both directions. This can be checked at the OUTPUT TO EASTFACING (WESTFACING) XMTR test point E2 of both video restorers.

(*b*) Terminals E11 and E12 should still be open-circuited at the repeater.

(3) At the repeater, place a short circuit across E3 and E4.

(*a*) This should insert channel 2 in both directions.

(*b*) There should still be an open circuit across E1 and E2 at the repeater.

(4) Place a short circuit across E13 and E14 of either terminal. Do both, one at a time. This should short-circuit E11 and E12 at the repeater.

Caution: There are approximately 40 volts dc on these terminals.

(5) Place a short circuit across E3 and E4 of either terminal. Do both, one at a time. This should short across E1 and E2 at the repeater.

Caution: There are approximately 40 volts dc on these terminals.

(6) Place the remote keying units in NORMAL OPERATION position at both terminals and at the repeater. Channels 1 and 2 should now be present at the terminals and at the repeater.

r. Audio Levels.

(1) Bypass the repeater by switching off the power supply +250V circuit breaker. The terminals should be in four-wire operation.

(2) Set the terminal audio levels as follows:

(*a*) Inject –4 dbm into the 4W TRANS of the west terminal channels.

(*b*) Set the modem OUTPUT AUDIO GAIN control of the corresponding demodulator in the east terminal for zero dbm output.

(*c*) Repeat this procedure on all channels, then modulate the east terminal and adjust the OUTPUT AUDIO GAIN of the west terminal modem demodulators.

(3) Switch on B+ at the repeater and place the PARTY LINE-PRIV switches in PRIV position. The repeater modems should still be in four-wire operation.

(4) Modulate channel 1 of the west terminal with –4 dbm, and monitor the westfacing channel 1 of the repeater at the 4W REC terminals. Adjust the modem OUTPUT AUDIO GAIN for zero dbm output. Repeat for channels 2 through 8.

(5) Repeat the procedure in subparagraph (4) above for the east terminal and the eastfacing modems of the AN/TCA–1.

(6) Place channels 1 and 2 PARTY LINE-PRIV switches in PARTY LINE position.

(7) Modulate channel 1 at the east terminal with –4 dbm. Monitor the output at the channel 1 PARTY LINE terminals at the repeater. There should be –8 ±1 dbm across 600 ohms. Also monitor the channel 1 4W REC at the west terminal. This should be zero dbm. Repeat the above procedure for channel 2.

(8) Now repeat the procedure in subparagraph (7) above, modulating at the west terminal and listening at the east terminal and the repeater.

(9) Modulate channel 1 at the repeater with zero dbm into the PARTY LINE terminals. Monitor the output of channel 1 of both terminals. This should be –6 ±1 dbm. Repeat for channel 2.

(10) Place the east and west terminals and channels 3 through 8 at the repeater in two-wire operation.

(11) Place an EE–8–B on the channel 1 2W terminals of both the east and west terminals and also on the PARTY LINE connections of channel 1 at the repeater. It should be possible to converse between all three phones simultaneously. Repeat for channel 2.

(12) Place channels 1 and 2 PARTY LINE-PRIV switches in PRIV, and 2W-4W switches in 2W operation.

(13) Place an EE–8–B on the 2W LINE terminals of the eastfacing channel 1 modem. It should be possible to converse with the east terminal channel 1 but not the west terminal.

(14) Place an EE–8–B on the 2W LINE terminals of the westfacing channel 1 modem. It should be possible to converse with the west terminal channel 1 but not the east terminal.

(15) Connect an EE–8–B on channels 2 through 8 (each one separately) 2W LINE terminals at the east terminal

and the 2W LINE terminals of the eastfacing channels 2 through 8. It should be possible to converse between the east terminal and the AN/TCA–1, but not the west terminal.

(16) Repeat the procedure in subparagraph (5) above for the west terminal and the westfacing channels at the AN/TCA–1.

s. Alarm Circuit. The alarm circuit should permit ringing disabling and should bypass the input pulse train to the output terminal if any of the following conditions take place: the input pulse train at E1 falling below an amplitude of .22 volt peak; failure of any tube in the positive pulse train section of the video restorer (V6 through V12); failure of any tube in the marker separator-shaping section of the video restorer (V19 through V26); high noise input to the video restorer.

Note. The output pulse train at E2 will be attenuated by a 6-db pad.

(1) Place the D&I-THRU switches in D&I position, 2W-4W switches in 4W position, and PARTY LINE-PRIV switches in PARTY LINE position.

(2) Connect a field Telephone EE–8–B across terminals E9 and E10, PARTY LINE, channel 1.

(3) Simulate all four conditions listed above. The telephone should not ring.

(4) In simulating the four conditions above, the ALARM indicator located on both the video restorer and the multiplexer subassembly should light. The ALARM buzzer should sound. Press the AUDIBLE ALARM DISCONNECT switch on the multiplexer subassembly front panel. The ALARM buzzer should no longer sound but the alarm indicator lights remain on. When everything is connected normally, the ALARM lights should extinguish.

t. Signal-to-noise Ratio (2W).

(1) Place all the PARTY LINE-PRIV switches in PRIV position.

(2) Measure the signal-to-noise ratio at the 2W LINE terminals of channels 1 through 10, 17, and 22 of both terminals and at the 2W LINE terminals of the repeater channels 1 through 8, under the following conditions:

  (*a*) All channels in THRU operation. (Do not measure channels 1 through 8 at the repeater in this condition.)

  (*b*) All channels in D&I operation.

Note. No reading should be greater than —55 dbm.

u. 23-channel Cross Talk. Terminate channels 1-3, 5, 6, 8-11, 17, 18, 22, and 23 with 600 ohms at the east and west terminals.

(1) Be sure that all D&I-THRU switches are in THRU position. All modems at the repeaters should be in 2W.

(2) At the west AN/TCC–13 terminal, press SEND button on control monitor, adjust SEND DBM on the test set to 0 DBM.

(3) At the west terminal turn the channel 1 modem selector switches to SR.

(4) At the east AN/TCC–13 terminal, press the REC button on the control monitor and F1A button on the test set.

(5) Turn the channel 2 modem selector switch to RR at east terminal and read meter on the test set. The allowable cross-talk reading is –48 dbm.

(6) Return the selector switches on both modems to OPER.

(7) Repeat the procedures in subparagraphs (3) through (6) above for the following channels (the allowable cross-talk reading is –48 dbm maximum):

Modulate (0 dbm)	Receive
West terminal channel into	East terminal channel
1	2
2	3
5	6
8	9
10	11
17	18
22	23
East terminal channel into	West terminal channel
1	2
2	3
5	6
8	9
10	11
17	18
22	23

(8) Place all repeater channels for D&I operation. PARTY LINE-PRIV switches should be in PRIV operation.

(9) On AN/TCC–13 terminals and AN/TCA–1 repeater, modulate by pressing SEND button on control monitor, adjusting SEND DBM to 0 DBM, and turning modem selector switch to SR. Receive by pressing REC button on control monitor, pushing F1A button on the audio test set, and turning modem selector switch to RR.

(10) Terminate channels 1, 2, 3, 5, 6, 8, and 9 with 600 ohms at both terminals and repeater. Take the following cross-talk readings (allowable cross talk is –48 dbm maximum):

Modulate (0 dbm)	Receive (by turning modem switch to RR)		
West terminal channel	East terminal channel	Westfacing repeater channel	Eastfacing repeater channel
1	1, 2	2	1, 2
2	2, 3	3	2, 3
5	5, 6	6	5, 6
8	8, 9		8
East terminal channel	West terminal channel	Eastfacing repeater channel	Westfacing repeater channel
1	1, 2	2	1, 2
2	2, 3	3	2, 3
5	5, 6	6	5, 6
8	8, 9		8
Westfacing repeater channel	West terminal channel	Eastfacing repeater channel	East terminal channel
1	2	1, 2	1, 2
2	3	2, 3	2, 3
5	6	5, 6	5, 6
8	9	8	8, 9
Eastfacing repeater channel	East terminal channel	Westfacing repeater channel	West terminal channel
1	2	1, 2	1, 2
2	3	2, 3	2, 3
5	6	5, 6	5, 6
8	9	8	8, 9

Note. No reading should be greater than —48 dbm.

v. 45-channel Operation. Connect the terminals for 45-channel operation. Connect the MASTER OUTPUTS TO RF (J5) of the master terminals to each of the pulse train inputs of the video restorer as in the 23-channel connection. The input pulse train consists of a positive 23-channel pulse train and a negative 23-channel pulse train, each being .5 volt from base line to peak, or 1 volt over-all peak to peak. The width of the pulses should be a maximum of .8 usec measured at the 50 per cent amplitude point. The spacing between the second positive marker pulse and the second negative marker pulse should be 2.6 ±.1 usec. Switches S1 of the video restorers should be placed in the 45 CHAN position. This will energize the filaments of V1 through V5 and permit the video restorer to accept the 45-channel pulse train.

(1) *Symmetry control.* Observe the OUTPUT TO EASTFACING (WESTFACING) XMTR test point E2 with

the oscilloscope. Adjust the SYM ADJ control until both positive and negative pulse trains are of equal amplitude. Measure the output pulse train. It shall be .4 to .6 volt peak to peak.

(2) *Channel signal-to-noise ratio.*

(*a*) Bypass the AN/TCA–1 by turning off the +250V circuit breaker on the AN/TCA–1 power supply.

(*b*) Set up correct audio levels by placing all 2W-4W switches of the test channels on the terminals in 2W. Modulate the 2W LINE terminals of both master and slave terminals of both directions, one at a time, with 0 dbm. Adjust the corresponding modem OUTPUT AUDIO GAIN controls for –3 dbm output.

(*c*) Place all PARTY LINE-PRIV switches in PRIV position.

(*d*) Turn on the +250 volts at the repeaters.

(*e*) Measure the signal-to-noise ratio at the 2W LINE terminals of channels 1 through 9 of all terminals (master and slave AN/TCC–13's), and at the 2W LINE terminals of the AN/TCA–1 channels 1 through 8. All channels in THRU operation. (Do not measure channel 1 through 8 in this condition.) All channels in D&I operation. No reading shall be greater than —48 dbm.

(3) *Channel cross talk (2W).*

(*a*) To modulate: press the SEND button on the control monitor, adjust the SEND DBM switch on the test set to 0 DBB, and turn the modem selector switch to SR. To receive: press the REC button on the control monitor, press the F1A button on the audio test set, and turn the modem selector switch to RR.

Note. After each check return the modem selector switch to OPER.

(*b*) Place all AN/TCA–1 D&I-THRU switches in THRU. Allowable cross talk in all cases is –38 dbm maximum.

1. Terminate channels 1, 2, 3, 5, 6, 8, 9, 10, 11, 17, 18, 22, and 23 of both master terminals with 600 ohms. Take the following cross-talk readings:

Modulate (0 dbm)	Receive
West master terminal channel into	East master terminal channel
1	2
2	3
5	6
8	9
10	11
17	18
22	23

2. Terminate channels 1, 2, 3, 5, 6, 8, 9, 10, 11, 17, 18, 22, and 23 of the west master and east slave terminals with 600 ohms. Take the following cross-talk readings:

Modulate (0 dbm)	Receive
West master terminal channel into	East slave terminal channel
1	1
2	2
5	5
8	8
10	10
17	17
22	22

3. Terminate channels 1-3, 5, 6, 8-11, 17, 18, 21, and 22 at the west slave and east master terminals with 600 ohms. Take the following cross-talk readings:

Modulate (0 dbm)	Receive
West slave terminal channel into	East master terminal channel
1	2
2	3
5	6
8	9
10	11
17	18
21	22

4. Terminate channels 1-3, 5, 6, 8-11, 18, 21, 22 at both slave terminals with 600 ohms. Take the following cross-talk readings:

Modulate (0 dbm)	Receive
West slave terminal channel into	East master terminal channel
1	2
2	3
5	6
8	9
10	11
17	18
21	22

(*c*) Repeat the measurements described in subparagraph (*b*) above by modulating the east terminal and receiving on the west terminal. No reading shall be greater than –38 dbm.

(*d*) Place all D&I THRU switches in each channel of the AN/TCA–1 in D&I position.

1. Terminate channels 1-3, 5, 6, 8, and 9 with 600 ohms at the west master, east master, east slave terminals and at the repeater. Take the following cross-talk readings (no reading shall be greater than –38 dbm):

Modulate (0 dbm)	Receive			
West master terminal	Westfacing repeater channel	Eastfacing repeater channel	East master terminal	East slave terminal
1	2	1, 2	1, 2	1
2	3	2, 3	2, 3	2
5	6	5, 6	5, 6	5
8	–	8	8, 9	8

2. Terminate channels 1-3, 5, 6, 8, and 9 with 600 ohms at the west slave, east master and slave terminals and at the repeater. Take the following cross-talk readings (no reading shall be greater than –38 dbm):

Modulate (0 dbm)	Receive			
West slave terminal	Westfacing repeater channel	Eastfacing repeater channel	East master terminal	East slave terminal
1	1, 2	1, 2	2	2
2	2, 3	2, 3	3	3
5	5, 6	5, 6	6	6
8	8	8	9	9

3. Terminate channels 1-3, 5, 6, 8, and 9 with 600 ohms at the east master, west master and slave terminals and at the repeater. Take the following cross-talk readings (no reading shall be greater than –38 dbm):

Modulate (0 dbm)	Receive			
East master terminal	Eastfacing repeater channel	Westfacing repeater channel	West master terminal	West slave terminal
1	2	1, 2	1, 2	1, 2
2	3	2, 3	2, 3	2, 3
5	6	5, 6	5, 6	5, 6
8	–	8	8, 9	8, 9

4. Terminate channels 1-3, 5, 6, 8, and 9 with 600 ohms at the east slave, west master and slave terminals and at the repeater. Take the following cross-talk readings (no reading shall be greater than –38 dbm):

Modulate (0 dbm)	Receive			
East slave terminal	Eastfacing repeater channel	Westfacing repeater channel	West master terminal	West slave terminal
1	1, 2	1, 2	2	2
2	2, 3	2, 3	3	3
5	5, 6	5, 6	6	6
8	8	8	9	9

5. Terminate channels 1-3, 5, 6, 8, and 9 with 600 ohms at the west master and slave and east master and slave terminals and at the repeaters. Take the following cross-talk readings (no reading shall be greater than –38 dbm):

Modulate (0 dbm)	Receive				
Westfacing repeater channel	West master terminal	West slave terminal	East master terminal	East slave terminal	Eastfacing repeater channel
1	2	1	1, 2	1	1, 2
2	3	2	2, 3	2	2, 3
5	6	5	5, 6	5	5, 6
8	9	8	8, 9	8	8

6. Terminate channels 1-3, 5, 6, 8, and 9 with 600 ohms at the east master and slave and west master and slave terminals and at the repeaters. Take the following cross-talk readings (no reading shall be greater than –38 dbm):

Modulate (0 dbm)	Receive				
Eastfacing repeater channel	East master terminal	East slave terminal	West master terminal	West slave terminal	Westfacing repeater channel
1	2	1	1, 2	1	1, 2
2	3	2	2, 3	2	2, 3
5	6	5	5, 6	5	5, 6
8	9	8	8, 9	8	8

CHAPTER 8

SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Section I. SHIPMENT AND LIMITED STORAGE

219. Disassembly of Equipment

The following instructions are recommended as a guide for preparing the multiplexer group for transportation and storage.

a. Make sure that all power switches are in the off position.

b. Disconnect all telephone lines from the binding posts alongside the delay line.

c. Disconnect all interconnecting power and signal cables, and store them in their respective Chests CY–250/U (par. 8).

d. Replace all cover caps.

e. Disconnect the oscilloscope probe and store it in the oscilloscope probe compartment.

f. Store the order-wire handset in the control monitor TEL SET compartment.

g. Tighten all captive screws securely with a screw driver.

h. Tighten all rack mounting screws securely.

i. Attach the front and rear cover of Case CY–1280/U to the multiplexer and test racks.

j. Wind up the 150-foot length of Electrical Power Cable Assembly CX–2440/U on Reel RC–405/TR.

220. Repacking for Shipment or Limited Storage

a. Procedure. The exact procedure used in repacking for shipment or limited storage depends upon the material available and the conditions under which the equipment is to be shipped or stored. Refer to paragraph 48 and reverse the instructions given in this paragraph.

b. Materials Required. When available, place a dehydrating agent such as silica gel inside the crates. Protect the cases with a waterproof paper barrier. Seal the seams of the paper barrier with a waterproof sealing compound or tape. Pack the protected cases in a padded wooden crate, and provide at least 3 inches of excelsior padding or some similar material between the paper barrier and the packing crate.

Section II. DEMOLITION OF MATERIEL TO PREVENT ENEMY USE

221. Authority for Demolition

The demolition procedures outlined in paragraph 223 will be used to prevent the enemy from using or salvaging this equipment. Demolition of the equipment will be accomplished only upon order of the commander.

222. Methods of Destruction

a. Smash. Smash the crystal, controls, tubes, coils, switches, capacitors, transformers, and headsets; use sledges, axes, handaxes, pickaxes, hammers, crowbars, or heavy tools.

b. Cut. Cut cords, headsets, and wiring; use axes, handaxes, or machetes.

c. Burn. Burn cords, resistors, capacitors, coils, wiring, and technical manuals; use gasoline, kerosene, oil, flame throwers, or incendiary grenades.

d. Bend. Bend panels, cabinet, and chassis.

e. Explosives. If explosives are necessary, use firearms, grenades, or TNT.

f. Disposal. Bury or scatter the destroyed parts in slit trenches, fox holes, or other holes, or throw them into streams.

g. Destroy. Destroy everything in the following order:

(1) Entire video restorer

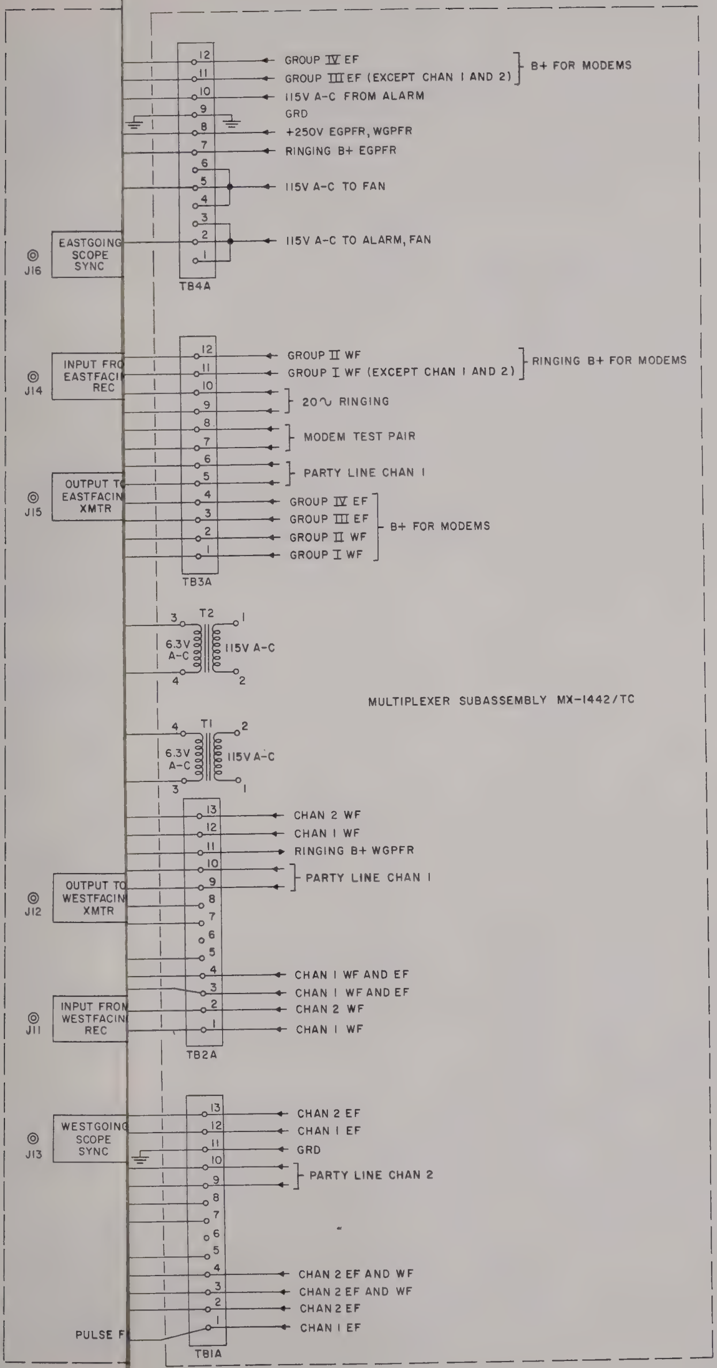
(2) Delay line

(3) All modems

(4) Oscilloscope

(5) Test set

(6) All remaining components


GROUP IV EF
GROUP III EF (EXCEPT CHAN 1 AND 2)
B+ FOR MODEMS
115V A-C FROM ALARM
GRD
+250V EGPFR, WGPFR
RINGING B+ EGPFR
115V A-C TO FAN
115V A-C TO ALARM, FAN
EASTGOING SCOPE SYNC
J16
TB4A
INPUT FRO EASTFACI REC
J14
GROUP II WF
GROUP I WF (EXCEPT CHAN 1 AND 2)
RINGING B+ FOR MODEMS
20~ RINGING
MODEM TEST PAIR
PARTY LINE CHAN 1
OUTPUT T EASTFACIN XMTR
J15
GROUP IV EF
GROUP III EF
GROUP II WF
GROUP I WF
B+ FOR MODEMS
TB3A
T2
6.3V A-C
115V A-C
MULTIPLEXER SUBASSEMBLY MX-1442/TC
T1
6.3V A-C
115V A-C
CHAN 2 WF
CHAN 1 WF
RINGING B+ WGPFR
PARTY LINE CHAN 1
OUTPUT TO WESTFACIN XMTR
J12
CHAN 1 WF AND EF
CHAN 1 WF AND EF
CHAN 2 WF
CHAN 1 WF
INPUT FRON WESTFACIN REC
J11
TB2A
CHAN 2 EF
CHAN 1 EF
GRD
PARTY LINE CHAN 2
WESTGOING SCOPE SYNC
J13
CHAN 2 EF AND WF
CHAN 2 EF AND WF
CHAN 2 EF
CHAN 1 EF
PULSE F
TB1A

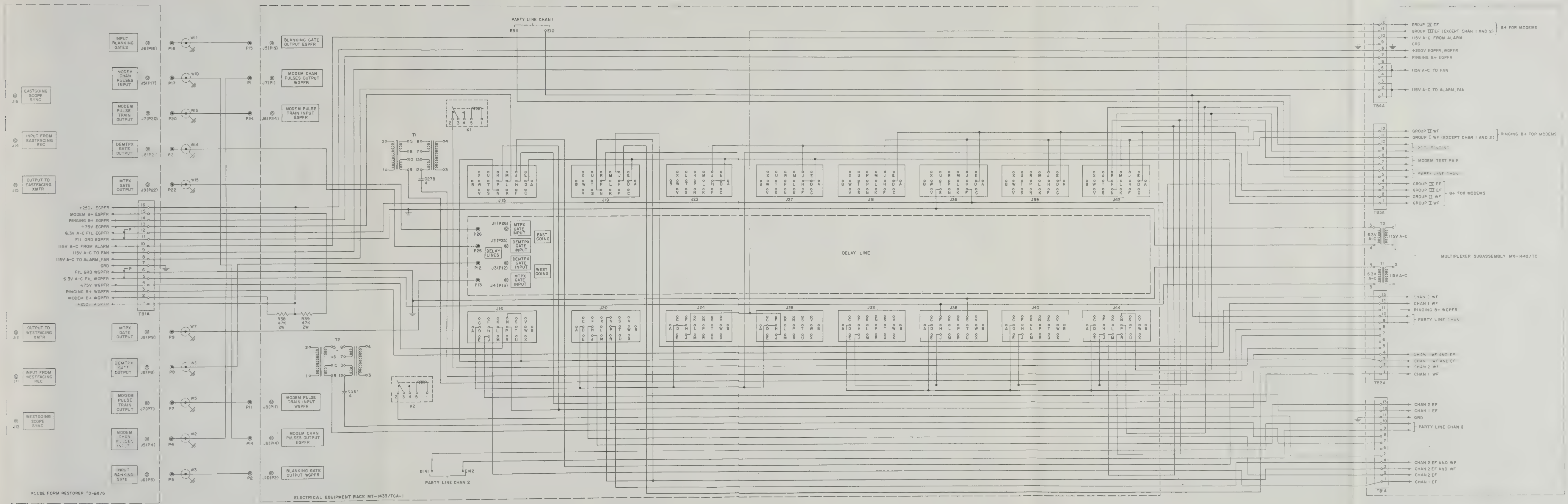
NOTES:

UNLESS OTHERWISE SHOWN RESISTORS ARE IN OHMS AND ONE HALF WATT CAPACITORS ARE IN UF.

WF — WESTFACING
EF — EASTFACING
WGPFR — WESTGOING PULSE FORM RESTORER
EGPFR — EASTGOING PULSE FORM RESTORER

TM5091-5

Figure 258. Multiplexer rack, over-all schematic diagram.


PULSE FORM RESTORER TD-68/G
ELECTRICAL EQUIPMENT RACK MT-1433/TCA-1
MULTIPLEXER SUBASSEMBLY MX-1442/TC
EASTGOING SCOPE SYNC
J16
INPUT FROM EASTFACING REC
J14
OUTPUT TO EASTFACING XMTR
J15
OUTPUT TO WESTFACING XMTR
J12
INPUT FROM WESTFACING REC
J11
WESTGOING SCOPE SYNC
J13
INPUT BLANKING GATES
J6(P18)
MODEM CHAN PULSES INPUT
J5(P17)
MODEM PULSE TRAIN OUTPUT
J7(P20)
DEMTPX GATE OUTPUT
J8(P21)
MTPX GATE OUTPUT
J9(P22)
MTPX GATE OUTPUT
J9(P9)
DEMTPX GATE OUTPUT
J8(P8)
MODEM PULSE TRAIN OUTPUT
J7(P7)
MODEM CHAN PULSES INPUT
J5(P4)
INPUT BANKING GATE
J6(P5)
P18
W11
P15
P17
W10
P1
P20
W13
P24
P2
W14
P22
W15
P9
W7
P8
W6
P7
W5
P11
P4
W2
P14
P5
W3
P2
BLANKING GATE OUTPUT EGPFR
J5(P15)
MODEM CHAN PULSES OUTPUT WGPFR
J7(P1)
MODEM PULSE TRAIN INPUT EGPFR
J6(P24)
MODEM PULSE TRAIN INPUT WGPFR
J9(P11)
MODEM CHAN PULSES OUTPUT EGPFR
J8(P14)
BLANKING GATE OUTPUT WGPFR
J10(P2)
+250V EGPFR
MODEM B+ EGPFR
RINGING B+ EGPFR
+75V EGPFR
6.3V A-C FIL EGPFR
FIL GRD EGPFR
115V A-C FROM ALARM
115V A-C TO FAN
115V A-C TO ALARM, FAN
GRD
FIL GRD WGPFR
6.3V A-C FIL WGPFR
+75V WGPFR
RINGING B+ WGPFR
MODEM B+ WGPFR
+250V WGPFR
P
TB1A
R38
47K
2W
R39
47K
2W
T1
C278
4
T2
C281
4
K1
K2
PARTY LINE CHAN 1
E9
E10
PARTY LINE CHAN 2
E141
E142
J15
J19
J23
J27
J31
J35
J39
J43
J16
J20
J24
J28
J32
J36
J40
J44
DELAY LINE
J1(P26)
MTPX GATE INPUT
P26
J2(P25)
DEMTPX GATE INPUT
P25
DELAY LINES
EAST GOING
J3(P12)
DEMTPX GATE INPUT
P12
J4(P13)
MTPX GATE INPUT
P13
WEST GOING
GROUP IV EF
GROUP III EF (EXCEPT CHAN 1 AND 2)
B+ FOR MODEMS
115V A-C FROM ALARM
GRD
+250V EGPFR, WGPFR
RINGING B+ EGPFR
115V A-C TO FAN
115V A-C TO ALARM, FAN
TB4A
GROUP II WF
GROUP I WF (EXCEPT CHAN 1 AND 2)
RINGING B+ FOR MODEMS
20CPS RINGING
MODEM TEST PAIR
PARTY LINE CHAN
GROUP IV EF
GROUP III EF
GROUP II WF
GROUP I WF
B+ FOR MODEMS
TB3A
T2
6.3V A-C
115V A-C
T1
6.3V A-C
115V A-C
CHAN 2 WF
CHAN 1 WF
RINGING B+ WGPFR
PARTY LINE CHAN
CHAN WF AND EF
CHAN WF AND EF
CHAN 2 WF
CHAN 1 WF
TB2A
CHAN 2 EF
CHAN 1 EF
GRD
PARTY LINE CHAN 2
CHAN 2 EF AND WF
CHAN 2 EF AND WF
CHAN 2 EF
CHAN 1 EF
TB1A

NOTES

UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS AND
ONE HALF WATT
CAPACITORS ARE IN UF

WF — WESTFACING
EF — EASTFACING
WGPFR — WESTGOING PULSE FORM RESTORER
EGPFR — EASTGOING PULSE FORM RESTORER

TM5091-5

Figure 258. Multiplexer rack, over-all schematic diagram.

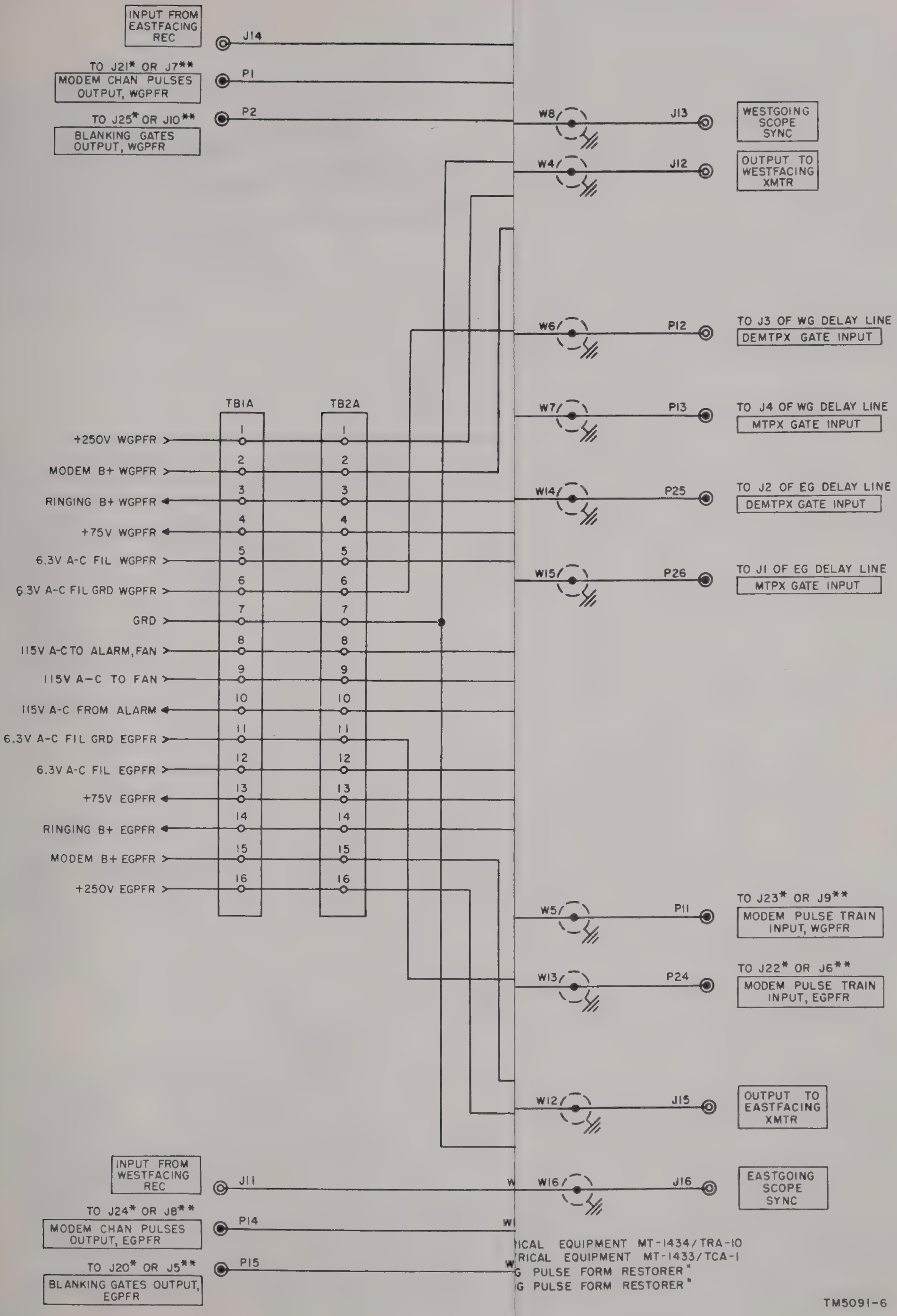
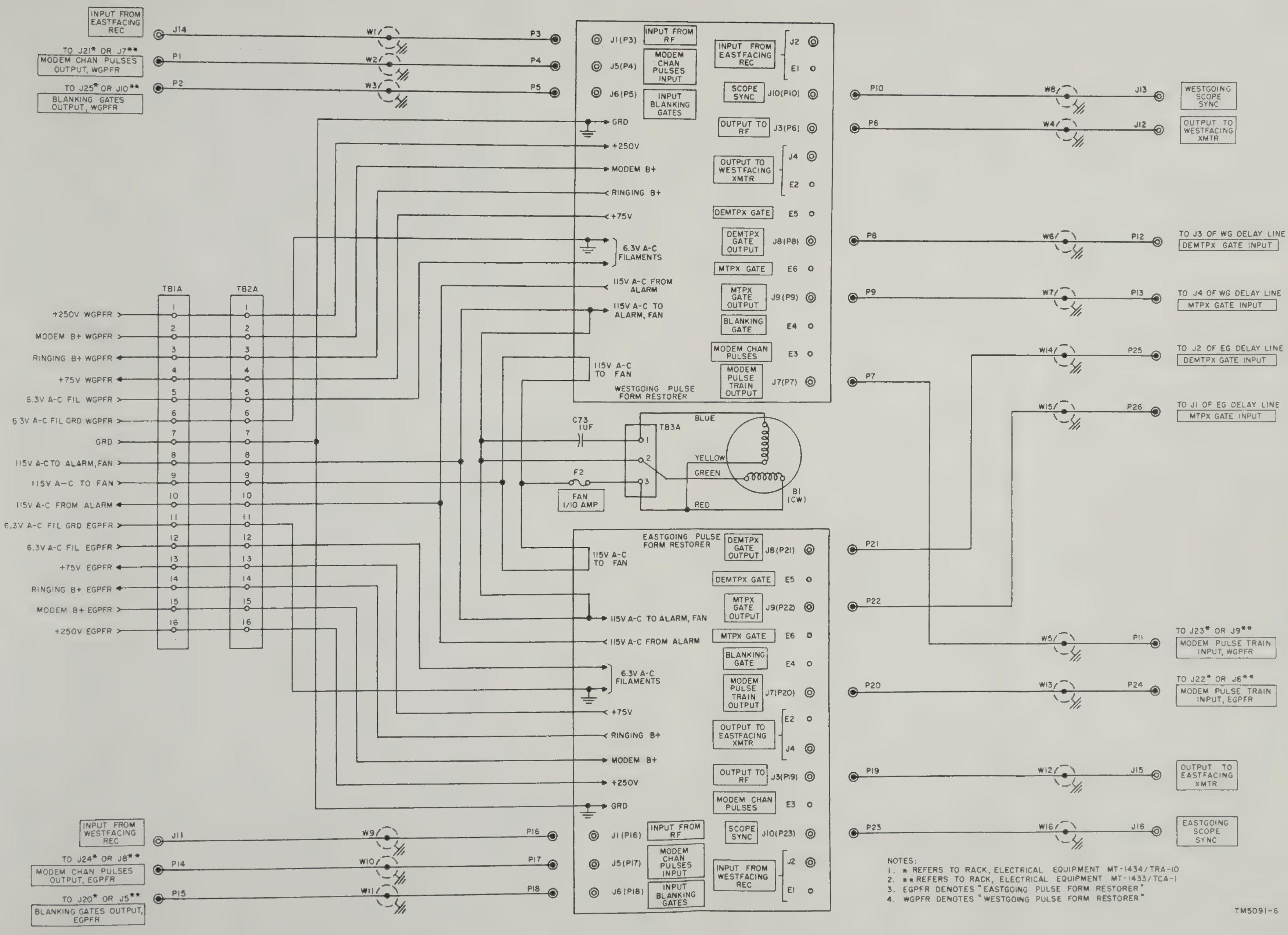

INPUT FROM EASTFACING REC
J14
TO J21* OR J7**
MODEM CHAN PULSES OUTPUT, WGPFR
P1
TO J25* OR J10**
BLANKING GATES OUTPUT, WGPFR
P2
W8
J13
WESTGOING SCOPE SYNC
W4
J12
OUTPUT TO WESTFACING XMTR
W6
P12
TO J3 OF WG DELAY LINE
DEMTPX GATE INPUT
W7
P13
TO J4 OF WG DELAY LINE
MTPX GATE INPUT
W14
P25
TO J2 OF EG DELAY LINE
DEMTPX GATE INPUT
W15
P26
TO J1 OF EG DELAY LINE
MTPX GATE INPUT
TB1A
TB2A
+250V WGPFR
MODEM B+ WGPFR
RINGING B+ WGPFR
+75V WGPFR
6.3V A-C FIL WGPFR
6.3V A-C FIL GRD WGPFR
GRD
115V A-C TO ALARM, FAN
115V A-C TO FAN
115V A-C FROM ALARM
6.3V A-C FIL GRD EGPFR
6.3V A-C FIL EGPFR
+75V EGPFR
RINGING B+ EGPFR
MODEM B+ EGPFR
+250V EGPFR
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
W5
P11
TO J23* OR J9**
MODEM PULSE TRAIN INPUT, WGPFR
W13
P24
TO J22* OR J6**
MODEM PULSE TRAIN INPUT, EGPFR
W12
J15
OUTPUT TO EASTFACING XMTR
INPUT FROM WESTFACING REC
J11
W
W16
J16
EASTGOING SCOPE SYNC
TO J24* OR J8**
MODEM CHAN PULSES OUTPUT, EGPFR
P14
W
TO J20* OR J5**
BLANKING GATES OUTPUT, EGPFR
P15
W
ICAL EQUIPMENT MT-1434/TRA-10
RICAL EQUIPMENT MT-1433/TCA-1
G PULSE FORM RESTORER"
G PULSE FORM RESTORER"
TM5091-6

Figure 259. Pulse Form Restorer TD–68/G, over-all schematic diagram.


INPUT FROM EASTFACING REC
J14
W1
P3
TO J21* OR J7**
MODEM CHAN PULSES OUTPUT, WGPFR
P1
W2
P4
TO J25* OR J10**
BLANKING GATES OUTPUT, WGPFR
P2
W3
P5
J1(P3)
INPUT FROM RF
J5(P4)
MODEM CHAN PULSES INPUT
J6(P5)
INPUT BLANKING GATES
INPUT FROM EASTFACING REC
J2
E1
SCOPE SYNC
J10(P10)
OUTPUT TO RF
J3(P6)
OUTPUT TO WESTFACING XMTR
J4
E2
DEMTPX GATE
E5
DEMTPX GATE OUTPUT
J8(P8)
MTPX GATE
E6
MTPX GATE OUTPUT
J9(P9)
BLANKING GATE
E4
MODEM CHAN PULSES
E3
MODEM PULSE TRAIN OUTPUT
J7(P7)
GRD
+250V
MODEM B+
RINGING B+
+75V
6.3V A-C FILAMENTS
115V A-C FROM ALARM
115V A-C TO ALARM, FAN
115V A-C TO FAN
WESTGOING PULSE FORM RESTORER
P10
W8
J13
WESTGOING SCOPE SYNC
P6
W4
J12
OUTPUT TO WESTFACING XMTR
P8
W6
P12
TO J3 OF WG DELAY LINE
DEMTPX GATE INPUT
P9
W7
P13
TO J4 OF WG DELAY LINE
MTPX GATE INPUT
W14
P25
TO J2 OF EG DELAY LINE
DEMTPX GATE INPUT
P7
W15
P26
TO J1 OF EG DELAY LINE
MTPX GATE INPUT
TB1A
TB2A
+250V WGPFR
MODEM B+ WGPFR
RINGING B+ WGPFR
+75V WGPFR
6.3V A-C FIL WGPFR
6.3V A-C FIL GRD WGPFR
GRD
115V A-C TO ALARM, FAN
115V A-C TO FAN
115V A-C FROM ALARM
6.3V A-C FIL GRD EGPFR
6.3V A-C FIL EGPFR
+75V EGPFR
RINGING B+ EGPFR
MODEM B+ EGPFR
+250V EGPFR
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
C73
1UF
TB3A
BLUE
YELLOW
GREEN
RED
F2
FAN
1/10 AMP
B1
(CW)
EASTGOING PULSE FORM RESTORER
DEMTPX GATE OUTPUT
J8(P21)
DEMTPX GATE
E5
MTPX GATE OUTPUT
J9(P22)
MTPX GATE
E6
BLANKING GATE
E4
MODEM PULSE TRAIN OUTPUT
J7(P20)
OUTPUT TO EASTFACING XMTR
E2
J4
OUTPUT TO RF
J3(P19)
MODEM CHAN PULSES
E3
INPUT FROM RF
J1(P16)
SCOPE SYNC
J10(P23)
MODEM CHAN PULSES INPUT
J5(P17)
INPUT FROM WESTFACING REC
J2
INPUT BLANKING GATES
J6(P18)
E1
P21
P22
W5
P11
TO J23* OR J9**
MODEM PULSE TRAIN INPUT, WGPFR
P20
W13
P24
TO J22* OR J6**
MODEM PULSE TRAIN INPUT, EGPFR
P19
W12
J15
OUTPUT TO EASTFACING XMTR
P23
W16
J16
EASTGOING SCOPE SYNC
INPUT FROM WESTFACING REC
J11
W9
P16
TO J24* OR J8**
MODEM CHAN PULSES OUTPUT, EGPFR
P14
W10
P17
TO J20* OR J5**
BLANKING GATES OUTPUT, EGPFR
P15
W11
P18
TM5091-6

NOTES:
1. * REFERS TO RACK, ELECTRICAL EQUIPMENT MT-1434/TRA-10
2. ** REFERS TO RACK, ELECTRICAL EQUIPMENT MT-1433/TCA-1
3. EGPFR DENOTES "EASTGOING PULSE FORM RESTORER"
4. WGPFR DENOTES "WESTGOING PULSE FORM RESTORER"

Figure 259. Pulse Form Restorer TD-68/G, over-all schematic diagram.

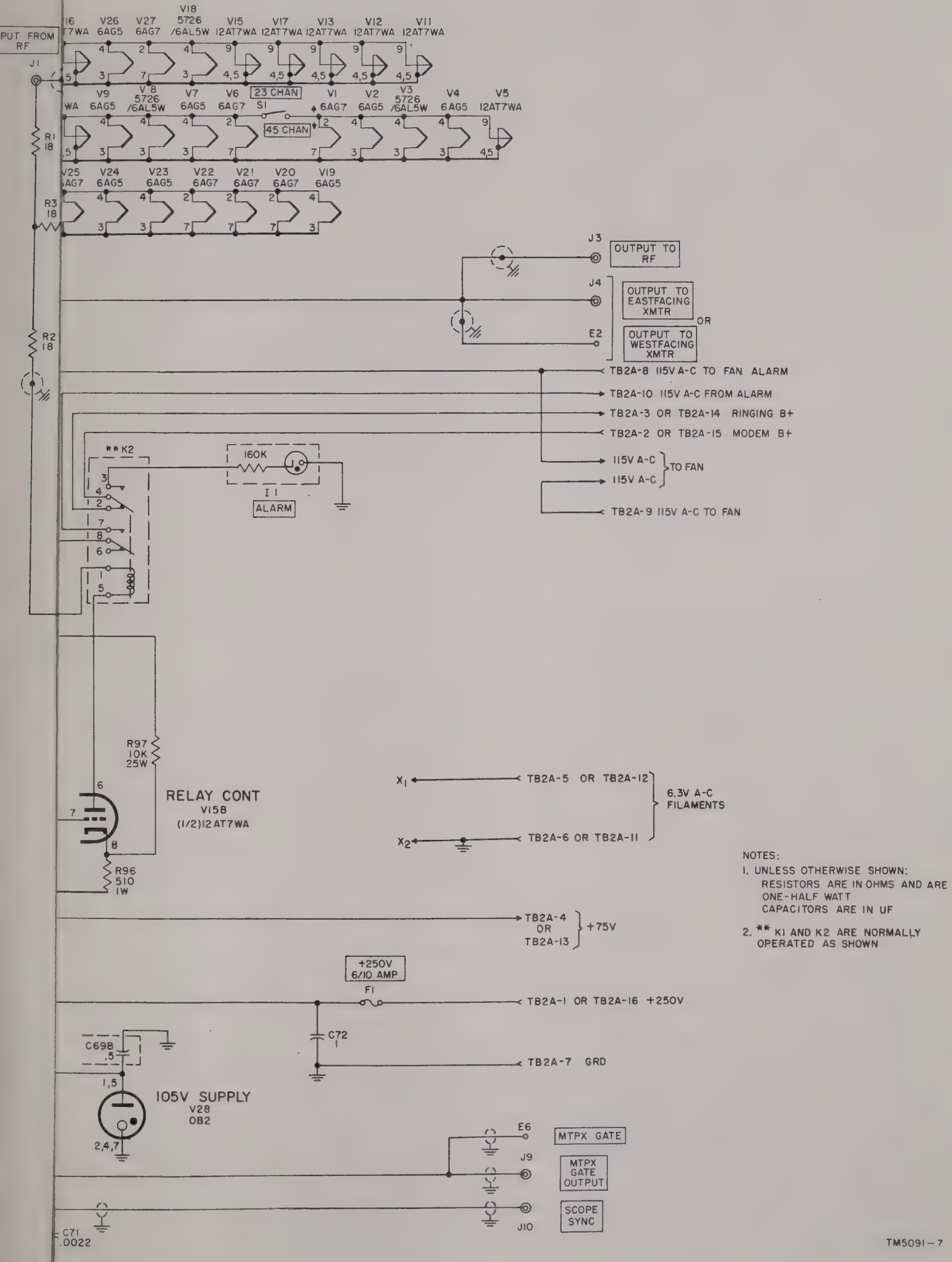
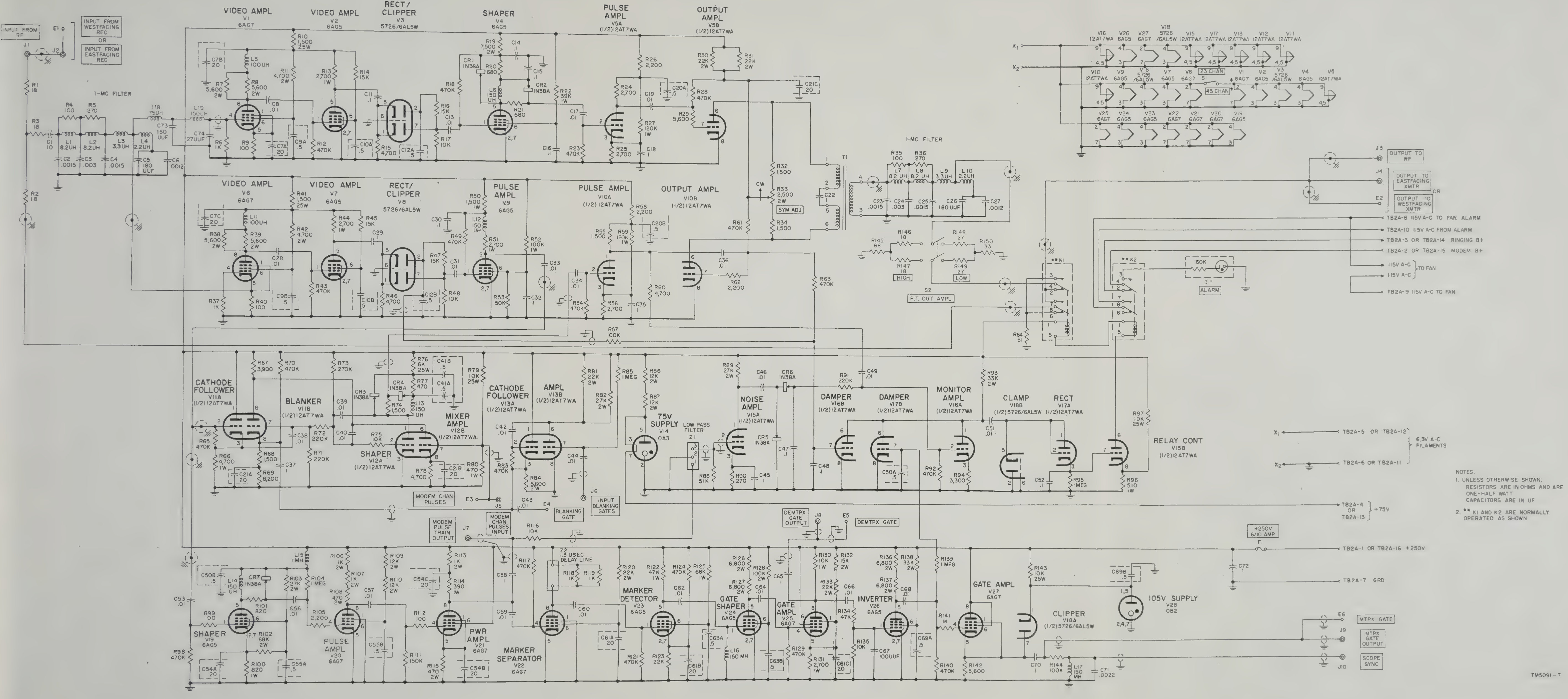
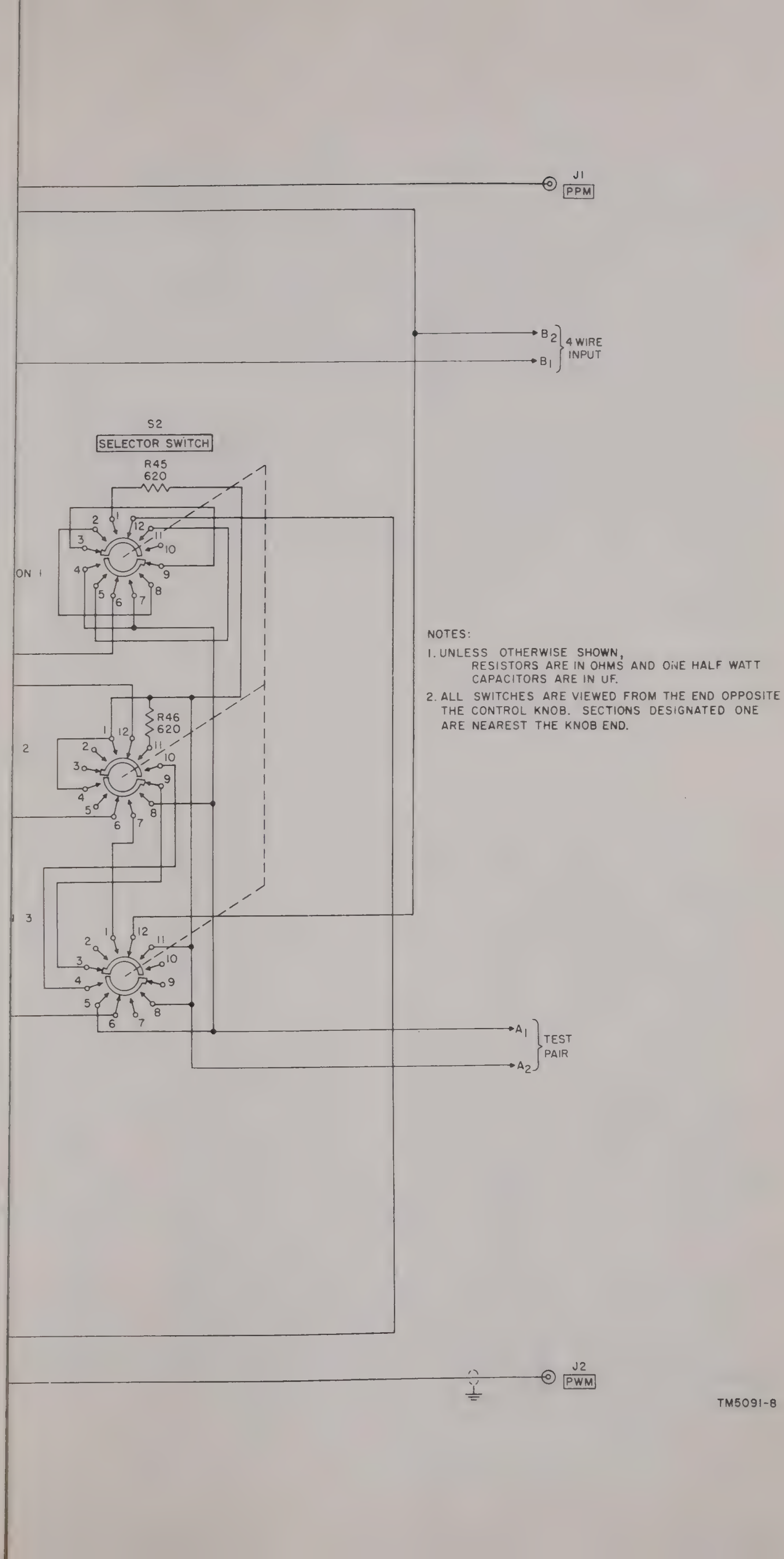

PUT FROM RF
J1
16 7WA
V26 6AG5
V27 6AG7
V18 5726 /6AL5W
V15 12AT7WA
V17 12AT7WA
V13 12AT7WA
V12 12AT7WA
V11 12AT7WA
WA
V9 6AG5
V8 5726 /6AL5W
V7 6AG5
V6 6AG7
23 CHAN
S1
45 CHAN
V1 6AG7
V2 6AG5
V3 5726 /6AL5W
V4 6AG5
V5 12AT7WA
V25 AG7
V24 6AG5
V23 6AG5
V22 6AG7
V21 6AG7
V20 6AG7
V19 6AG5
R1 18
R3 18
R2 18
J3
OUTPUT TO RF
J4
OUTPUT TO EASTFACING XMTR
OR
E2
OUTPUT TO WESTFACING XMTR
TB2A-8 115V A-C TO FAN ALARM
TB2A-10 115V A-C FROM ALARM
TB2A-3 OR TB2A-14 RINGING B+
TB2A-2 OR TB2A-15 MODEM B+
**K2
160K
I1
ALARM
115V A-C
115V A-C
TO FAN
TB2A-9 115V A-C TO FAN
R97 10K 25W
RELAY CONT
V15B
(1/2)12AT7WA
R96 510 1W
X1
TB2A-5 OR TB2A-12
X2
TB2A-6 OR TB2A-11
6.3V A-C FILAMENTS
TB2A-4 OR TB2A-13
+75V
+250V 6/10 AMP
F1
TB2A-1 OR TB2A-16 +250V
C72 1
TB2A-7 GRD
C69B .5
105V SUPPLY
V28
OB2
E6
MTPX GATE
J9
MTPX GATE OUTPUT
SCOPE SYNC
J10
C71 .0022
NOTES:
1. UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS AND ARE ONE-HALF WATT
CAPACITORS ARE IN UF
2. ** K1 AND K2 ARE NORMALLY OPERATED AS SHOWN
TM5091-7

Figure 260. Video restorer, over-all schematic diagram.



INPUT FROM RF
INPUT FROM WESTFACING REC
OR
INPUT FROM EASTFACING REC
J1
J2
E1
I-MC FILTER
VIDEO AMPL V1 6AG7
VIDEO AMPL V2 6AG5
RECT/CLIPPER V3 5726/6AL5W
SHAPER V4 6AG5
PULSE AMPL V5A (1/2)12AT7WA
OUTPUT AMPL V5B (1/2)12AT7WA
VIDEO AMPL V6 6AG7
VIDEO AMPL V7 6AG5
RECT/CLIPPER V8 5726/6AL5W
PULSE AMPL V9 6AG5
PULSE AMPL V10A (1/2)12AT7WA
OUTPUT AMPL V10B (1/2)12AT7WA
SYM ADJ
CW
T1
I-MC FILTER
HIGH
LOW
S2
P.T. OUT AMPL
**K1
**K2
I 1
ALARM
23 CHAN
S1
45 CHAN
X1
X2
OUTPUT TO RF
OUTPUT TO EASTFACING XMTR
OR
OUTPUT TO WESTFACING XMTR
J3
J4
E2
TB2A-8 115V A-C TO FAN ALARM
TB2A-10 115V A-C FROM ALARM
TB2A-3 OR TB2A-14 RINGING B+
TB2A-2 OR TB2A-15 MODEM B+
115V A-C
115V A-C
TO FAN
TB2A-9 115V A-C TO FAN
CATHODE FOLLOWER V11A (1/2)12AT7WA
BLANKER V11B (1/2)12AT7WA
MIXER AMPL V12B (1/2)12AT7WA
SHAPER V12A (1/2)12AT7WA
CATHODE FOLLOWER V13A (1/2)12AT7WA
AMPL V13B (1/2)12AT7WA
75V SUPPLY V14 0A3
LOW PASS FILTER Z1
NOISE AMPL V15A (1/2)12AT7WA
DAMPER V16B (1/2)12AT7WA
DAMPER V17B (1/2)12AT7WA
MONITOR AMPL V16A (1/2)12AT7WA
CLAMP V18B (1/2)5726/6AL5W
RECT V17A (1/2)12AT7WA
RELAY CONT V15B (1/2)12AT7WA
TB2A-5 OR TB2A-12
TB2A-6 OR TB2A-11
6.3V A-C FILAMENTS
MODEM CHAN PULSES
E3
J5
E4
BLANKING GATE
J6
INPUT BLANKING GATES
TB2A-4 OR TB2A-13 +75V
MODEM PULSE TRAIN OUTPUT
J7
MODEM CHAN PULSES INPUT
DEMTPX GATE OUTPUT
J8
E5
DEMTPX GATE
+250V 6/10 AMP
F1
TB2A-1 OR TB2A-16 +250V
TB2A-7 GRD
Z2 1.3 USEC DELAY LINE
SHAPER V19 6AG5
PULSE AMPL V20 6AG7
PWR AMPL V21 6AG7
MARKER SEPARATOR V22 6AG7
MARKER DETECTOR V23 6AG5
GATE SHAPER V24 6AG5
GATE AMPL V25 6AG7
INVERTER V26 6AG5
GATE AMPL V27 6AG7
CLIPPER V18A (1/2)5726/6AL5W
105V SUPPLY V28 0B2
E6
MTPX GATE
J9
MTPX GATE OUTPUT
J10
SCOPE SYNC
NOTES:
1. UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS AND ARE ONE-HALF WATT
CAPACITORS ARE IN UF
2. ** K1 AND K2 ARE NORMALLY OPERATED AS SHOWN
TM5091-7

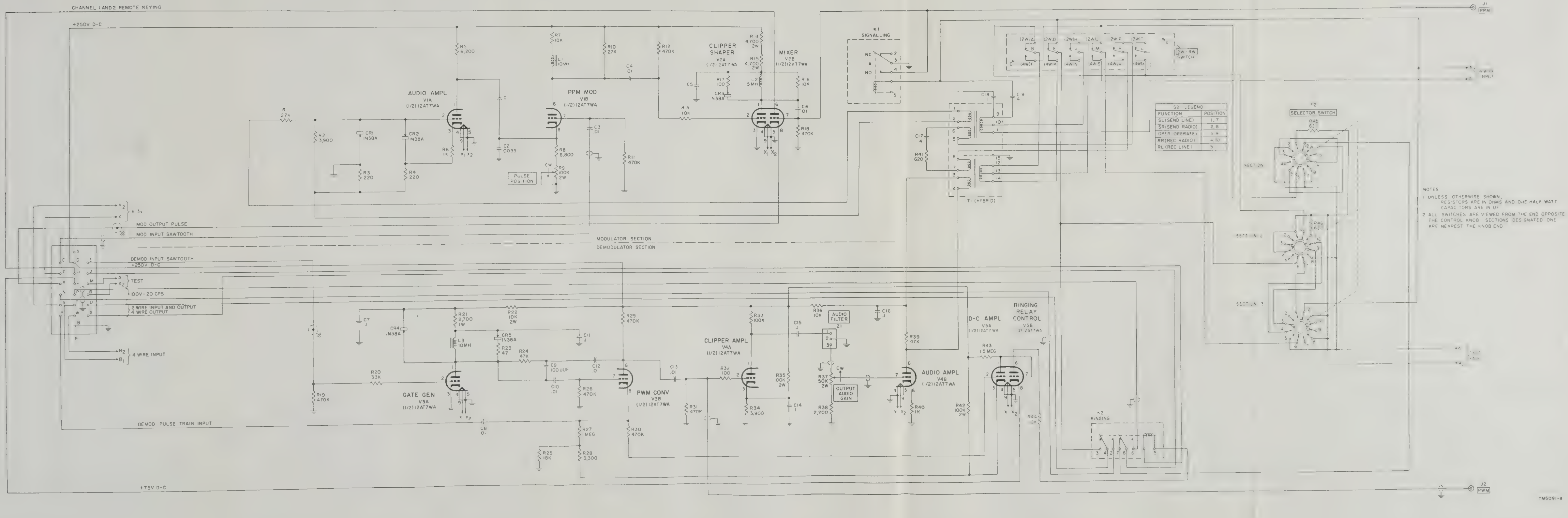
Figure 260. Video restorer, over-all schematic diagram.


J1
PPM
B2
B1
4 WIRE INPUT
S2
SELECTOR SWITCH
R45
620
ON 1
1
2
3
4
5
6
7
8
9
10
11
12
R46
620
2
3
A1
A2
TEST PAIR
J2
PWM
TM5091-8

NOTES:

1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS AND ONE HALF WATT CAPACITORS ARE IN UF.
2. ALL SWITCHES ARE VIEWED FROM THE END OPPOSITE THE CONTROL KNOB. SECTIONS DESIGNATED ONE ARE NEAREST THE KNOB END.

Figure 261. Telephone Modem MD–179/TC, over-all schematic diagram.



CHANNEL 1 AND 2 REMOTE KEYING
+250V D-C
AUDIO AMPL
V1A
(1/2)12AT7WA
PPM MOD
V1B
(1/2)12AT7WA
CLIPPER SHAPER
V2A
(1/2)12AT7WA
MIXER
V2B
(1/2)12AT7WA
PULSE POSITION
K1
SIGNALLING
T1 (HYBRID)
SELECTOR SWITCH
S2W-4W SWITCH
J1 PPM
J2 PWM
SECTION 1
SECTION 2
SECTION 3
MOD OUTPUT PULSE
MOD INPUT SAWTOOTH
MODULATOR SECTION
DEMODULATOR SECTION
DEMOD INPUT SAWTOOTH
+250V D-C
TEST
100V-20 CPS
2 WIRE INPUT AND OUTPUT
4 WIRE OUTPUT
4 WIRE INPUT
6.3v
P1
GATE GEN
V3A
(1/2)12AT7WA
PWM CONV
V3B
(1/2)12AT7WA
CLIPPER AMPL
V4A
(1/2)12AT7WA
AUDIO FILTER
Z1
OUTPUT AUDIO GAIN
AUDIO AMPL
V4B
(1/2)12AT7WA
D-C AMPL
V5A
(1/2)12AT7WA
RINGING RELAY CONTROL
V5B
(1/2)12AT7WA
K2
RINGING
DEMOD PULSE TRAIN INPUT
+75V D-C
TM5091-8

S2 LEGEND	
FUNCTION	POSITION
SL(SEND LINE)	1,7
SR(SEND RADIO)	2,8
OPER (OPERATE)	3,9
RR(REC RADIO)	4,10
RL (REC LINE)	5

NOTES

1 UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS AND ONE HALF WATT
CAPACITORS ARE IN UF

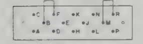
2 ALL SWITCHES ARE VIEWED FROM THE END OPPOSITE THE CONTROL KNOB. SECTIONS DESIGNATED ONE ARE NEAREST THE KNOB END

Figure 261. Telephone Modem MD-179/TC, over-all schematic diagram.

NOTES

1 UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS CAPACITORS ARE IN UF

2. P3 THRU P18 ARE ALL WIRED IDENTICALLY AS FOLLOWS


C
F
K
N
R
B
E
J
M
A
D
H
L
P

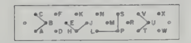
3. FOR [DBI] OPERATION P3 MATES WITH J13

P3	A	B	C	D	E	F	H	J	K	L	M	N	P	R
J13	A	B	C	D	E	F	H	J	K	L	M	N	P	R

4. FOR [THRU] OPERATION P3 MATES WITH J13

P3	A	B	C	D	E	F	H	J	K	L	M	N	P	R
J13	R	M	P	N	J	L	K	E	H	F	B	D	C	A

5. P1 AND P2 ARE WIRED IDENTICALLY AS FOLLOWS


C
F
K
N
S
V
X
B
E
J
M
R
U
A
D
H
L
P
T
W

6 THE FOLLOWING NON-STANDARD ABBREVIATIONS ARE USED

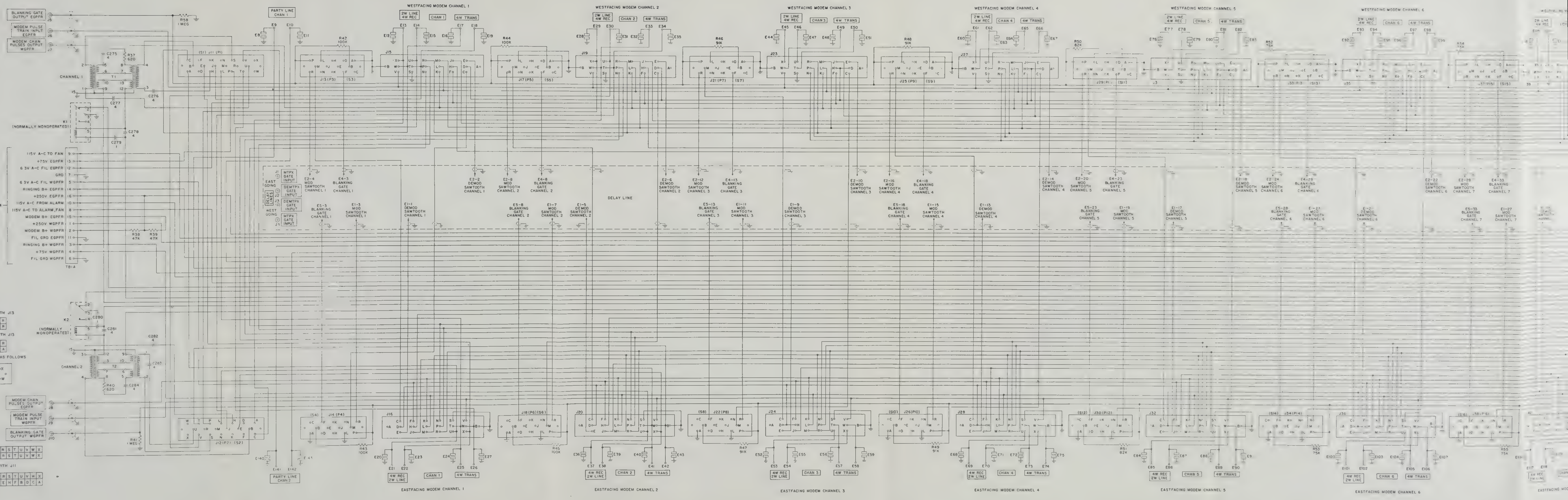
PFR —— PULSE FORM RESTORER
EG —— EASTGOING
WG —— WESTGOING
EF —— EASTFACING
WF —— WESTFACING

7. FOR PARTY LINE OPERATION P1 MATES WITH J11

P1	A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V	W	X
J11	A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V	W	X

8 FOR PRIVATE OPERATION P1 MATES WITH J11

P1	A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V	W	X
J11	X	U	W	V	R	T	S	M	P	N	J	L	K	E	H	F	B	D	C	A


BLANKING GATE OUTPUT EGPFR
J5
MODEM PULSE TRAIN INPUT EGPFR
J6
MODEM CHAN PULSES OUTPUT WGPFR
J7
R58 1 MEG
PARTY LINE CHAN 1
E8
E9
E10
E11
C275 4
R37 620
CHANNEL 1
T1
C276 4
C277 4
K1 (NORMALLY NONOPERATED)
C278 4
C279 1
(S1) J11 (P1)
J13 (P3)
TO PULSE FORM RESTORER TD-68/G
115V A-C TO FAN 9
+75V EGPFR 13
6.3V A-C FIL EGPFR 12
GRD 7
6.3V A-C FIL WGPFR 5
RINGING B+ EGPFR 14
+250V EGPFR 16
115V A-C FROM ALARM 10
115V A-C TO ALARM, FAN 8
MODEM B+ EGPFR 15
+250V WGPFR 1
MODEM B+ WGPFR 2
FIL GRD EGPFR 11
RINGING B+ WGPFR 3
+75V WGPFR 4
FIL GRD WGPFR 6
TB1A
R38 47K
R39 47K
WESTFACING MODEM CHANNEL 1
2W LINE 4W REC
CHAN 1
4W TRANS
E12 E13 E14 E15 E16 E17 E18 E19
R42 100K
J15
(S3)
R44 100K
J17 (P5) (S5)
WESTFACING MODEM CHANNEL 2
2W LINE 4W REC
CHAN 2
4W TRANS
E28 E29 E30 E31 E32 E33 E34 E35
J19
R46 91K
J21 (P7) (S7)
WESTFACING MODEM CHANNEL 3
2W LINE 4W REC
CHAN 3
4W TRANS
E44 E45 E46 E47 E48 E49 E50 E51
J23
R48 91K
J25 (P9) (S9)
WESTFACING MODEM CHANNEL 4
2W LINE 4W REC
CHAN 4
4W TRANS
E60 E61 E62 E63 E64 E65 E66 E67
J27
R50 82K
J29 (P11) (S11)
WESTFACING MODEM CHANNEL 5
2W LINE 4W REC
CHAN 5
4W TRANS
E76 E77 E78 E79 E80 E81 E82 E83
J31
R52 75K
J33 (P13) (S13)
WESTFACING MODEM CHANNEL 6
2W LINE 4W REC
CHAN 6
4W TRANS
E92 E93 E94 E95 E96 E97 E98 E99
J35
R54 75K
J37 (P15) (S15)
J39
2W LINE 4W REC
EAST GOING
WEST GOING
DELAY LINES
J1 MTPX GATE INPUT
J2 DEMTPX GATE INPUT
J3 DEMTPX GATE INPUT
J4 MTPX GATE INPUT
E2-4 MOD SAWTOOTH CHANNEL 1
E4-3 BLANKING GATE CHANNEL 1
E5-3 BLANKING GATE CHANNEL 1
E1-3 MOD SAWTOOTH CHANNEL 1
E1-1 DEMOD SAWTOOTH CHANNEL 1
E2-2 DEMOD SAWTOOTH CHANNEL 1
E2-8 MOD SAWTOOTH CHANNEL 2
E4-8 BLANKING GATE CHANNEL 2
E5-8 BLANKING GATE CHANNEL 2
E1-7 MOD SAWTOOTH CHANNEL 2
E1-5 DEMOD SAWTOOTH CHANNEL 2
DELAY LINE
E2-6 DEMOD SAWTOOTH CHANNEL 2
E2-12 MOD SAWTOOTH CHANNEL 3
E4-13 BLANKING GATE CHANNEL 3
E5-13 BLANKING GATE CHANNEL 3
E1-11 MOD SAWTOOTH CHANNEL 3
E1-9 DEMOD SAWTOOTH CHANNEL 3
E2-10 DEMOD SAWTOOTH CHANNEL 3
E2-16 MOD SAWTOOTH CHANNEL 4
E4-18 BLANKING GATE CHANNEL 4
E5-18 BLANKING GATE CHANNEL 4
E1-15 MOD SAWTOOTH CHANNEL 4
E1-13 DEMOD SAWTOOTH CHANNEL 4
E2-14 DEMOD SAWTOOTH CHANNEL 4
E2-20 MOD SAWTOOTH CHANNEL 5
E4-23 BLANKING GATE CHANNEL 5
E5-23 BLANKING GATE CHANNEL 5
E1-19 MOD SAWTOOTH CHANNEL 5
E1-17 DEMOD SAWTOOTH CHANNEL 5
E2-18 DEMOD SAWTOOTH CHANNEL 5
E2-24 MOD SAWTOOTH CHANNEL 6
E4-28 BLANKING GATE CHANNEL 6
E5-28 BLANKING GATE CHANNEL 6
MOD SAWTOOTH CHANNEL 6
DEMOD SAWTOOTH CHANNEL 6
E2-22 DEMOD SAWTOOTH CHANNEL 6
E2-28 MOD SAWTOOTH CHANNEL 7
E4-33 BLANKING GATE CHANNEL 7
E5-33 BLANKING GATE CHANNEL 7
E1-27 MOD SAWTOOTH CHANNEL 7
K2 (NORMALLY NONOPERATED)
C280
C281 4
C282 4
C283 4
CHANNEL 2
T2
R40 620
C284 4
MODEM CHAN PULSES OUTPUT EGPFR
J8
MODEM PULSE TRAIN INPUT WGPFR
J9
BLANKING GATE OUTPUT WGPFR
J10
R41 1 MEG
J12 (P2) (S2)
E140 E141 E142 E143
PARTY LINE CHAN 2
(S4) J14 (P4)
R43 100K
J16
E20 E21 E22 E23 E24 E25 E26 E27
4W REC 2W LINE
CHAN 1
4W TRANS
EASTFACING MODEM CHANNEL 1
J18 (P6) (S6)
R45 100K
J20
E36 E37 E38 E39 E40 E41 E42 E43
4W REC 2W LINE
CHAN 2
4W TRANS
EASTFACING MODEM CHANNEL 2
(S8) J22 (P8)
R47 91K
J24
E52 E53 E54 E55 E56 E57 E58 E59
4W REC 2W LINE
CHAN 3
4W TRANS
EASTFACING MODEM CHANNEL 3
(S10) J26 (P10)
R49 91K
J28
E68 E69 E70 E71 E72 E73 E74 E75
4W REC 2W LINE
CHAN 4
4W TRANS
EASTFACING MODEM CHANNEL 4
(S12) J30 (P12)
R51 82K
J32
E84 E85 E86 E87 E88 E89 E90 E91
4W REC 2W LINE
CHAN 5
4W TRANS
EASTFACING MODEM CHANNEL 5
(S14) J34 (P14)
R53 75K
J36
E100 E101 E102 E103 E104 E105 E106 E107
4W REC 2W LINE
CHAN 6
4W TRANS
EASTFACING MODEM CHANNEL 6
(S16) J38 (P16)
R55 75K
E116 E117 E118
4W REC 2W LINE
EASTFACING MOD

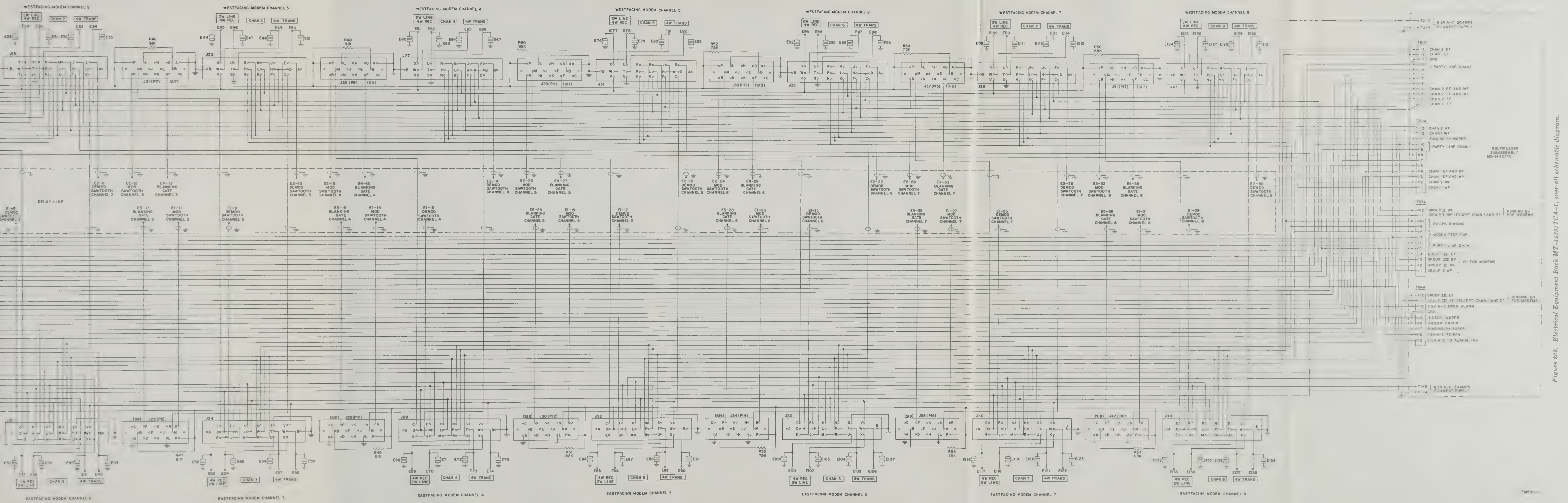
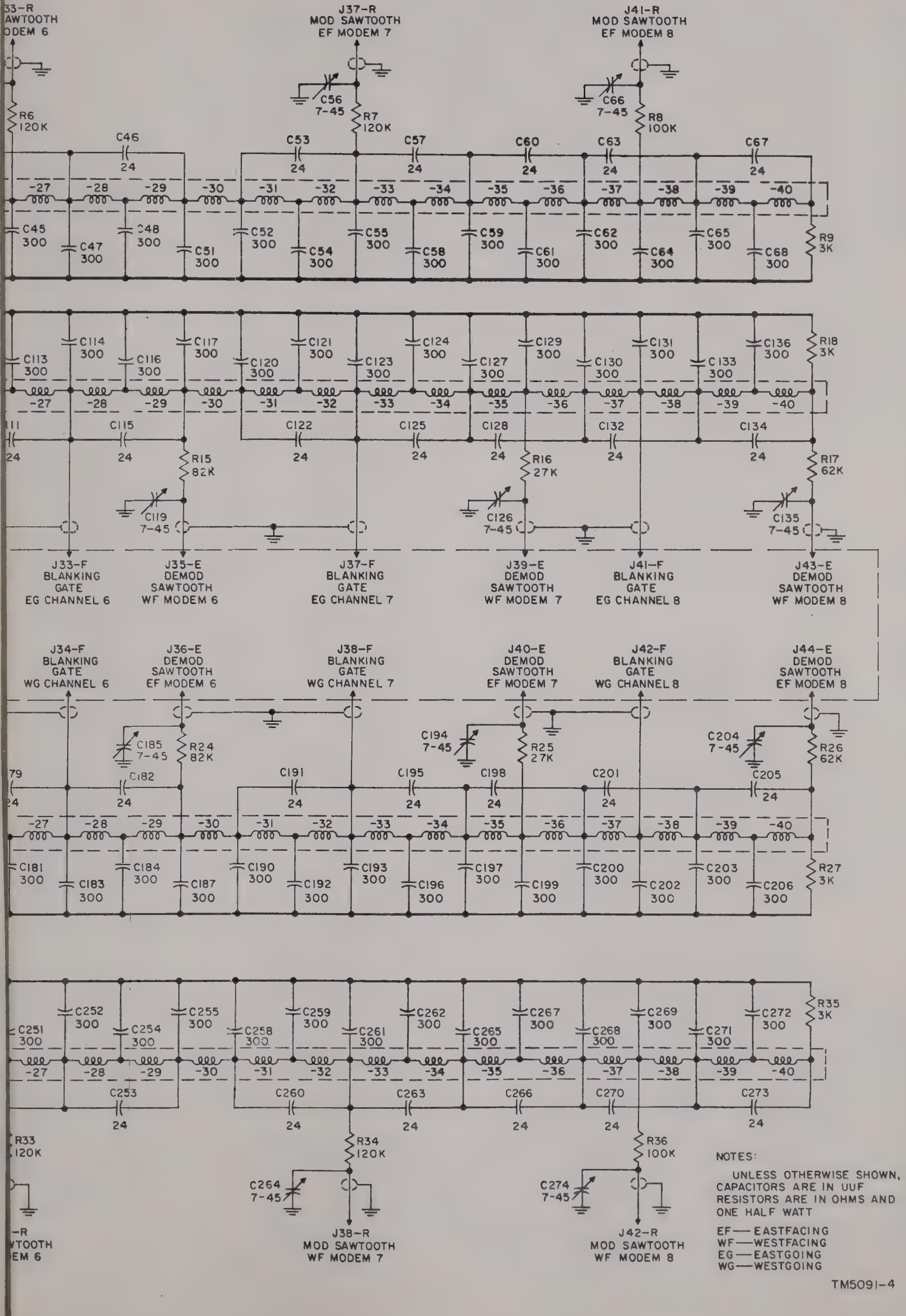

WESTFACING MODEM CHANNEL 2
WESTFACING MODEM CHANNEL 3
WESTFACING MODEM CHANNEL 4
WESTFACING MODEM CHANNEL 5
WESTFACING MODEM CHANNEL 6
WESTFACING MODEM CHANNEL 7
WESTFACING MODEM CHANNEL 8
2W LINE 4W REC
4W TRANS
DELAY LINE
E2-6 DEMOD SAWTOOTH CHANNEL 2
E2-12 MOD SAWTOOTH CHANNEL 3
E4-13 BLANKING GATE CHANNEL 3
E5-13 BLANKING GATE CHANNEL 3
E1-11 MOD SAWTOOTH CHANNEL 3
E1-9 DEMOD SAWTOOTH CHANNEL 3
E2-10 DEMOD SAWTOOTH CHANNEL 3
E2-16 MOD SAWTOOTH CHANNEL 4
E4-18 BLANKING GATE CHANNEL 4
E5-18 BLANKING GATE CHANNEL 4
E1-15 MOD SAWTOOTH CHANNEL 4
E1-13 DEMOD SAWTOOTH CHANNEL 4
E2-14 DEMOD SAWTOOTH CHANNEL 4
E2-20 MOD SAWTOOTH CHANNEL 5
E4-23 BLANKING GATE CHANNEL 5
E5-23 BLANKING GATE CHANNEL 5
E1-19 MOD SAWTOOTH CHANNEL 5
E1-17 DEMOD SAWTOOTH CHANNEL 5
E2-18 DEMOD SAWTOOTH CHANNEL 5
E2-24 MOD SAWTOOTH CHANNEL 6
E4-28 BLANKING GATE CHANNEL 6
E5-28 BLANKING GATE CHANNEL 6
E1-23 MOD SAWTOOTH CHANNEL 6
E1-21 DEMOD SAWTOOTH CHANNEL 6
E2-22 DEMOD SAWTOOTH CHANNEL 6
E2-28 MOD SAWTOOTH CHANNEL 7
E4-33 BLANKING GATE CHANNEL 7
E5-33 BLANKING GATE CHANNEL 7
E1-27 MOD SAWTOOTH CHANNEL 7
E1-25 DEMOD SAWTOOTH CHANNEL 7
E2-26 DEMOD SAWTOOTH CHANNEL 7
E2-32 MOD SAWTOOTH CHANNEL 8
E4-38 BLANKING GATE CHANNEL 8
E5-38 BLANKING GATE CHANNEL 8
E1-31 MOD SAWTOOTH CHANNEL 8
E1-29 DEMOD SAWTOOTH CHANNEL 8
E2-30 DEMOD SAWTOOTH CHANNEL 8
T2-3 6.3V A-C 30AMPS FILAMENT SUPPLY
TB A
CHAN 2 EF
CHAN 1 EF
GRD
PARTY LINE CHAN2
CHAN 2 EF AND WF
CHAN 2 EF AND WF
CHAN 2 EF
CHAN 1 EF
TB2A
CHAN 2 WF
CHAN 1 WF
RINGING B+ WGPFR
PARTY LINE CHAN 1
CHAN 1 EF AND WF
CHAN 1 EF AND WF
CHAN 2 WF
CHAN 1 WF
MULTIPLEXER SUBASSEMBLY MX-1442/TC
TB3A
GROUP II WF
GROUP I WF (EXCEPT CHAN 1 AND 2)
RINGING B+ FOR MODEMS
20 CPS RINGING
MODEM TEST PAIR
PARTY LINE CHAN
GROUP IV EF
GROUP III EF
GROUP II WF
GROUP I WF
B+ FOR MODEMS
TB4A
GROUP IV EF
GROUP III EF (EXCEPT CHAN 1 AND 2)
RINGING B+ FOR MODEMS
115V A-C FROM ALARM
GRD
+250V WGPFR
+250V EGPFR
RINGING B+ EGPFR
115V A-C TO FAN
115V A-C TO ALARM, FAN
T1-3 6.3V A-C 30AMPS FILAMENT SUPPLY
EASTFACING MODEM CHANNEL 2
EASTFACING MODEM CHANNEL 3
EASTFACING MODEM CHANNEL 4
EASTFACING MODEM CHANNEL 5
EASTFACING MODEM CHANNEL 6
EASTFACING MODEM CHANNEL 7
EASTFACING MODEM CHANNEL 8
4W REC 2W LINE
TM509

Figure 262. Electrical Equipment Rack MT-1433/TCA-1, over-all schematic diagram.


33-R
AWTOOTH
ODEM 6
J37-R
MOD SAWTOOTH
EF MODEM 7
J41-R
MOD SAWTOOTH
EF MODEM 8
C56
7-45
C66
7-45
R6
120K
R7
120K
R8
100K
C46
24
C53
24
C57
24
C60
24
C63
24
C67
24
-27
-28
-29
-30
-31
-32
-33
-34
-35
-36
-37
-38
-39
-40
C45
300
C47
300
C48
300
C51
300
C52
300
C54
300
C55
300
C58
300
C59
300
C61
300
C62
300
C64
300
C65
300
C68
300
R9
3K
C113
300
C114
300
C116
300
C117
300
C120
300
C121
300
C123
300
C124
300
C127
300
C129
300
C130
300
C131
300
C133
300
C136
300
R18
3K
111
24
C115
24
C122
24
C125
24
C128
24
C132
24
C134
24
R15
82K
R16
27K
R17
62K
C119
7-45
C126
7-45
C135
7-45
J33-F
BLANKING
GATE
EG CHANNEL 6
J35-E
DEMOD
SAWTOOTH
WF MODEM 6
J37-F
BLANKING
GATE
EG CHANNEL 7
J39-E
DEMOD
SAWTOOTH
WF MODEM 7
J41-F
BLANKING
GATE
EG CHANNEL 8
J43-E
DEMOD
SAWTOOTH
WF MODEM 8
J34-F
BLANKING
GATE
WG CHANNEL 6
J36-E
DEMOD
SAWTOOTH
EF MODEM 6
J38-F
BLANKING
GATE
WG CHANNEL 7
J40-E
DEMOD
SAWTOOTH
EF MODEM 7
J42-F
BLANKING
GATE
WG CHANNEL 8
J44-E
DEMOD
SAWTOOTH
EF MODEM 8
C185
7-45
R24
82K
C194
7-45
R25
27K
C204
7-45
R26
62K
79
24
C182
24
C191
24
C195
24
C198
24
C201
24
C205
24
C181
300
C183
300
C184
300
C187
300
C190
300
C192
300
C193
300
C196
300
C197
300
C199
300
C200
300
C202
300
C203
300
C206
300
R27
3K
C251
300
C252
300
C254
300
C255
300
C258
300
C259
300
C261
300
C262
300
C265
300
C267
300
C268
300
C269
300
C271
300
C272
300
R35
3K
C253
24
C260
24
C263
24
C266
24
C270
24
C273
24
R33
120K
R34
120K
R36
100K
C264
7-45
C274
7-45
-R
TOOTH
EM 6
J38-R
MOD SAWTOOTH
WF MODEM 7
J42-R
MOD SAWTOOTH
WF MODEM 8
TM5091-4

NOTES:

UNLESS OTHERWISE SHOWN,
CAPACITORS ARE IN UUF
RESISTORS ARE IN OHMS AND
ONE HALF WATT

EF—EASTFACING
WF—WESTFACING
EG—EASTGOING
WG—WESTGOING

Figure 263. Delay line, over-all schematic diagram.

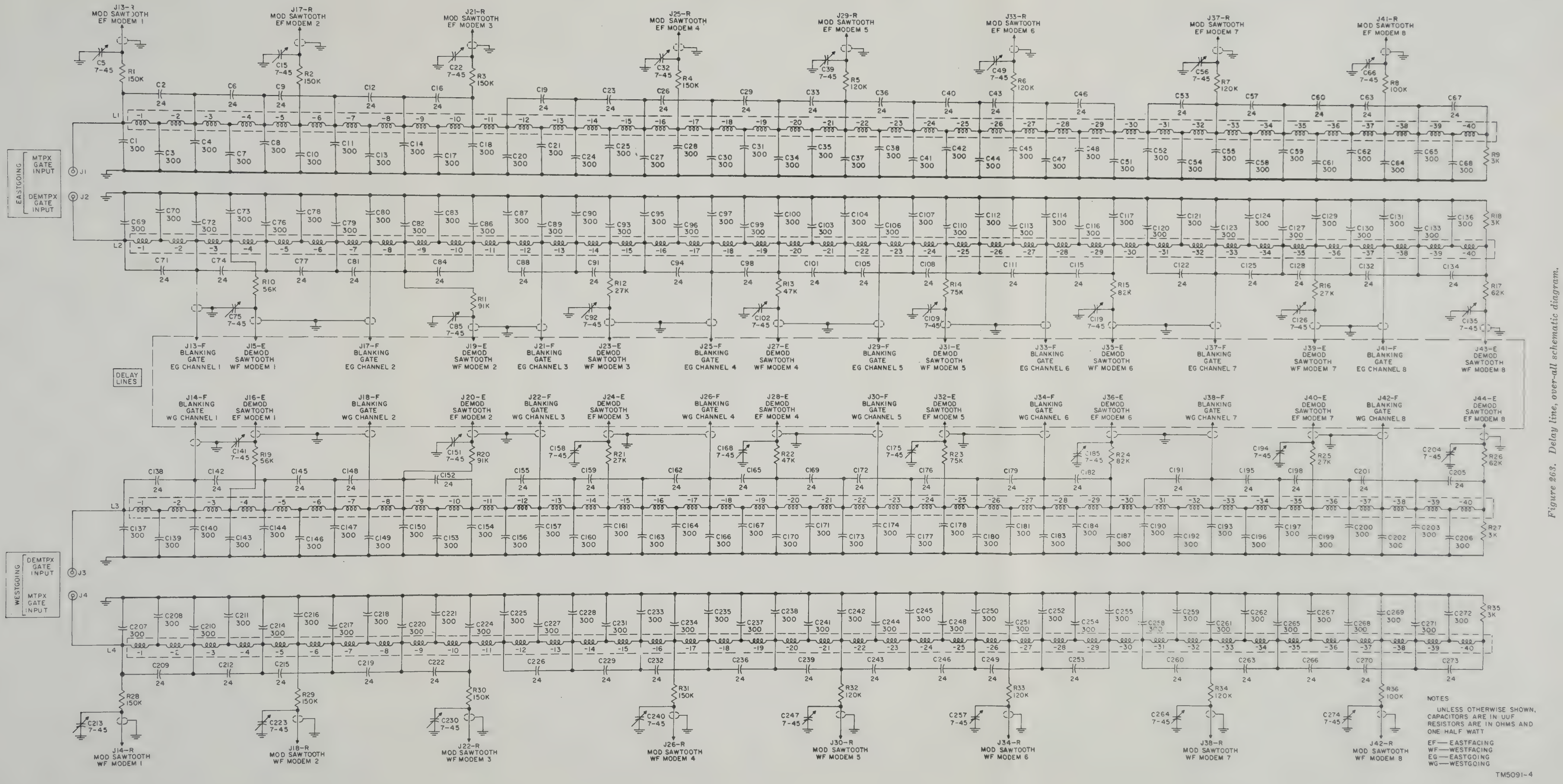
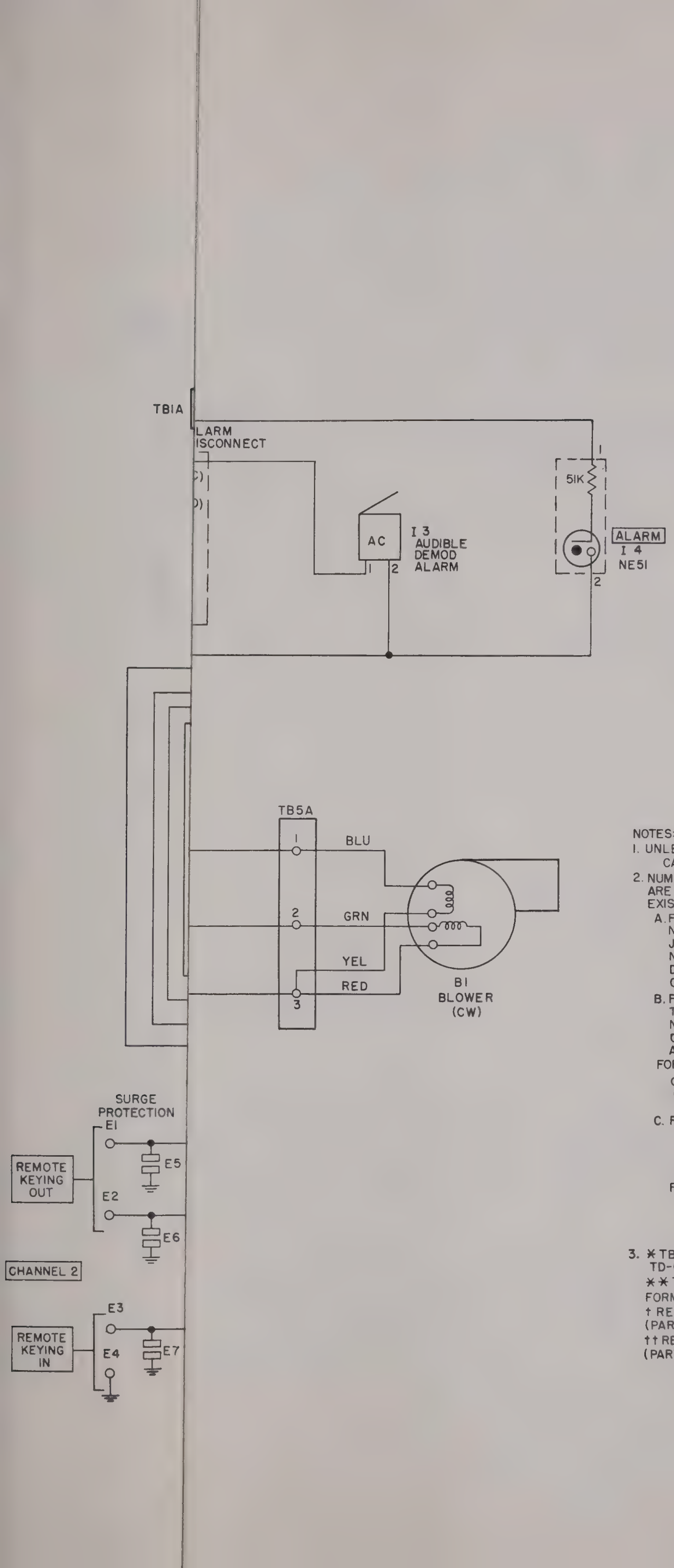

J13–R MOD SAWTOOTH EF MODEM 1
J17–R MOD SAWTOOTH EF MODEM 2
J21–R MOD SAWTOOTH EF MODEM 3
J25–R MOD SAWTOOTH EF MODEM 4
J29–R MOD SAWTOOTH EF MODEM 5
J33–R MOD SAWTOOTH EF MODEM 6
J37–R MOD SAWTOOTH EF MODEM 7
J41–R MOD SAWTOOTH EF MODEM 8
EASTGOING
MTPX GATE INPUT
DEMTPX GATE INPUT
J1
J2
L1
L2
L3
L4
DELAY LINES
J13–F BLANKING GATE EG CHANNEL 1
J15–E DEMOD SAWTOOTH WF MODEM 1
J17–F BLANKING GATE EG CHANNEL 2
J19–E DEMOD SAWTOOTH WF MODEM 2
J21–F BLANKING GATE EG CHANNEL 3
J23–E DEMOD SAWTOOTH WF MODEM 3
J25–F BLANKING GATE EG CHANNEL 4
J27–E DEMOD SAWTOOTH WF MODEM 4
J29–F BLANKING GATE EG CHANNEL 5
J31–E DEMOD SAWTOOTH WF MODEM 5
J33–F BLANKING GATE EG CHANNEL 6
J35–E DEMOD SAWTOOTH WF MODEM 6
J37–F BLANKING GATE EG CHANNEL 7
J39–E DEMOD SAWTOOTH WF MODEM 7
J41–F BLANKING GATE EG CHANNEL 8
J43–E DEMOD SAWTOOTH WF MODEM 8
J14–F BLANKING GATE WG CHANNEL 1
J16–E DEMOD SAWTOOTH EF MODEM 1
J18–F BLANKING GATE WG CHANNEL 2
J20–E DEMOD SAWTOOTH EF MODEM 2
J22–F BLANKING GATE WG CHANNEL 3
J24–E DEMOD SAWTOOTH EF MODEM 3
J26–F BLANKING GATE WG CHANNEL 4
J28–E DEMOD SAWTOOTH EF MODEM 4
J30–F BLANKING GATE WG CHANNEL 5
J32–E DEMOD SAWTOOTH EF MODEM 5
J34–F BLANKING GATE WG CHANNEL 6
J36–E DEMOD SAWTOOTH EF MODEM 6
J38–F BLANKING GATE WG CHANNEL 7
J40–E DEMOD SAWTOOTH EF MODEM 7
J42–F BLANKING GATE WG CHANNEL 8
J44–E DEMOD SAWTOOTH EF MODEM 8
WESTGOING
DEMTPX GATE INPUT
MTPX GATE INPUT
J3
J4
J14–R MOD SAWTOOTH WF MODEM 1
J18–R MOD SAWTOOTH WF MODEM 2
J22–R MOD SAWTOOTH WF MODEM 3
J26–R MOD SAWTOOTH WF MODEM 4
J30–R MOD SAWTOOTH WF MODEM 5
J34–R MOD SAWTOOTH WF MODEM 6
J38–R MOD SAWTOOTH WF MODEM 7
J42–R MOD SAWTOOTH WF MODEM 8
R1 150K
R2 150K
R3 150K
R4 150K
R5 120K
R6 120K
R7 120K
R8 100K
R9 3K
R10 56K
R11 91K
R12 27K
R13 47K
R14 75K
R15 82K
R16 27K
R17 62K
R18 3K
R19 56K
R20 91K
R21 27K
R22 47K
R23 75K
R24 82K
R25 27K
R26 62K
R27 3K
R28 150K
R29 150K
R30 150K
R31 150K
R32 120K
R33 120K
R34 120K
R35 3K
R36 100K
NOTES
UNLESS OTHERWISE SHOWN, CAPACITORS ARE IN UUF RESISTORS ARE IN OHMS AND ONE HALF WATT
EF—EASTFACING
WF—WESTFACING
EG—EASTGOING
WG—WESTGOING
TM5091-4

Figure 263. Delay line, over-all schematic diagram.


TB1A
LARM
ISCONNECT
C)
D)
AC
I 3
AUDIBLE
DEMOD
ALARM
1
2
1
51K
ALARM
I 4
NE51
2
TB5A
1
2
3
BLU
GRN
YEL
RED
B1
BLOWER
(CW)
SURGE
PROTECTION
E1
E5
REMOTE
KEYING
OUT
E2
E6
CHANNEL 2
E3
REMOTE
KEYING
IN
E4
E7

NOTES:

1. UNLESS OTHERWISE SHOWN:
   CAPACITORS ARE IN UF.
2. NUMBERS NEXT TO SQUARES ON J1, J2, J3 AND J4 ARE FOR REFERENCE ONLY, AND DO NOT EXIST PHYSICALLY.
   - A. FOR REMOTE OPERATION, TERMINAL NUMBERS NEXT TO CIRCLES ON J1, J2, J3 AND J4 MATE WITH CORRESPONDING TERMINAL NUMBERS OF P1 AND P2 ON THE SCHEMATIC DIAGRAM OF CONTROL, REMOTE SWITCHING C-1509/TC.
   - B. FOR NORMAL OPERATION, TERMINAL NUMBERS NEXT TO CIRCLES ON J1, J2, J3 AND J4 MATE WITH NUMBERS OF P1, AND P2, WHICH ARE REFERENCED CORRESPONDINGLY NEXT TO SQUARES ALONGSIDE THE CIRCLES ON J1, J2, J3, AND J4.

   FOR EXAMPLE:

   O1 ☐32 ON J1 INDICATES THAT FOR REMOTE OPERATION TERMINAL 1 OF J1 MATES WITH TERMINAL 32 OF P1 OR P2.
   - C. FOR REMOTE OPERATION:
     - J1 MATES WITH P2 } CHANNEL 2
     - J2 MATES WITH P1 } CHANNEL 2
     - J3 MATES WITH P2 } CHANNEL 1
     - J4 MATES WITH P1 } CHANNEL 1

   FOR NORMAL OPERATION:
     - J1 MATES WITH P1 } CHANNEL 2
     - J2 MATES WITH P2 } CHANNEL 2
     - J3 MATES WITH P1 } CHANNEL 1
     - J4 MATES WITH P2 } CHANNEL 1
3. ✱ TB1A IS TERMINAL BOARD ON MULTIPLEXER TD-60/TCC-13. (PART OF AN/TCC-13)

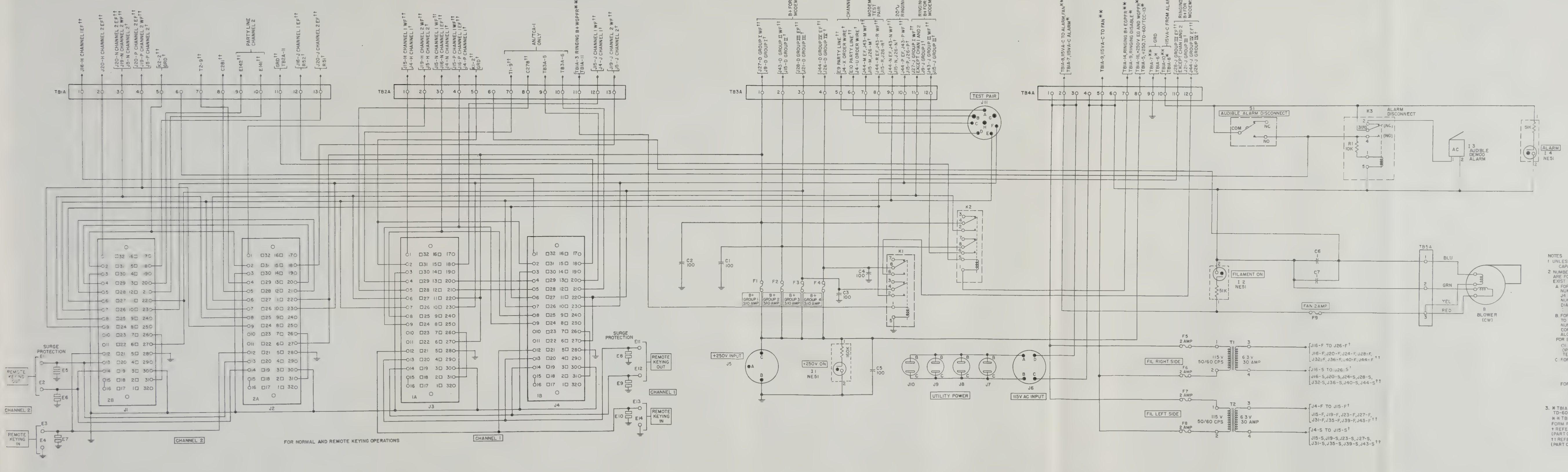
   ✱✱ TB1A IS TERMINAL BOARD ON PULSE FORM RESTORER TD-68/G (PART OF AN/TCA-1).

   † REFERS TO RACK, ELEC EQUIP MT-1165/TCC-13. (PART OF AN/TCC-13).

   †† REFERS TO RACK, ELEC EQUIP MT-1433/TCA-1. (PART OF AN/TCA-1).

TM5091-9

Figure 264. Multiplexer Subassembly MX-1442/TC, over-all schematic diagram.


TB1A
TB2A
TB3A
TB4A
TEST PAIR
J11
S1
AUDIBLE ALARM DISCONNECT
K3
ALARM DISCONNECT
I 3
AUDIBLE DEMOD ALARM
ALARM
I 4
NE51
K2
K1
C2 100
C1 100
F1
F2
F3
F4
C4 100
C3 100
FILAMENT ON
I 2
NE51
C6
C7
TB5A
BLU
GRN
YEL
RED
B
BLOWER (CW)
FAN 2AMP
F9
SURGE PROTECTION
REMOTE KEYING OUT
REMOTE KEYING IN
CHANNEL 2
CHANNEL 1
J1
J2
J3
J4
FOR NORMAL AND REMOTE KEYING OPERATIONS
+250V INPUT
J5
+250V ON
I1
NE51
C5 100
J10
J9
J8
J7
UTILITY POWER
J6
115V AC INPUT
FIL RIGHT SIDE
FIL LEFT SIDE
F5 2 AMP
F6 2 AMP
F7 2 AMP
F8 2 AMP
T1
T2
115 V 50/60 CPS
6.3 V 30 AMP

NOTES

1 UNLESS OTHERWISE SHOWN CAPACITORS ARE IN UF

2 NUMBERS NEXT TO SQUARES ON J1, J2, J3 AND J4 ARE FOR REFERENCE ONLY, AND DO NOT EXIST PHYSICALLY

A FOR REMOTE OPERATION, TERMINAL NUMBERS NEXT TO CIRCLES ON J1, J2, J3 AND J4 MATE WITH CORRESPONDING TERMINAL NUMBERS OF P1 AND P2 ON THE SCHEMATIC DIAGRAM OF CONTROL, REMOTE SWITCHING [illegible]

B. FOR NORMAL OPERATION, TERMINAL NUMBERS NEXT TO CIRCLES ON J1, J2, J3 AND J4 MATE WITH NUMBERS OF P1, AND P2, WHICH ARE REFERENCED CORRESPONDINGLY NEXT TO SQUARES ALONGSIDE THE CIRCLES ON J1, J2, J3, AND J4

FOR EXAMPLE

O1 ☐32 ON J1 INDICATES THAT FOR REMOTE OPERATION TERMINAL 1 OF J1 MATES WITH TERMINAL 32 OF P1 OR P2

C FOR REMOTE OPERATION

J1 MATES WITH P2 } CHANNEL 2
J2 MATES WITH P1 }
J3 MATES WITH P2 } CHANNEL 1
J4 MATES WITH P1 }

FOR NORMAL OPERATION

J1 MATES WITH P1 } CHANNEL 2
J2 MATES WITH P2 }
J3 MATES WITH P1 } CHANNEL 1
J4 MATES WITH P2 }

3. * TB1A IS TERMINAL BOARD ON MULTIPLEXER TD-60/TCC-13. (PART OF AN/TCC-13)

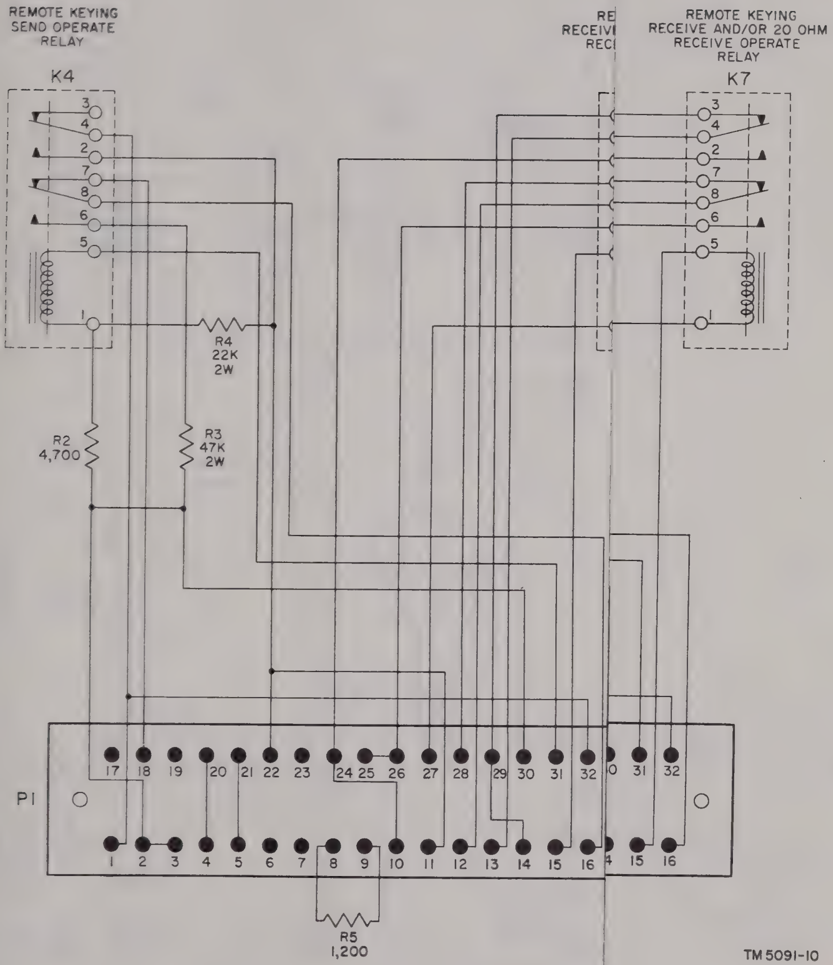
** TB1A IS TERMINAL BOARD ON PULSE FORM RESTORER TD-68/G (PART OF AN/TCA-1)

† REFERS TO RACK, ELEC EQUIP MT-1165/TCC-13 (PART OF AN/TCC-13).

†† REFERS TO RACK, ELEC EQUIP MT-1433/TCA-1 (PART OF AN/TCA-1)

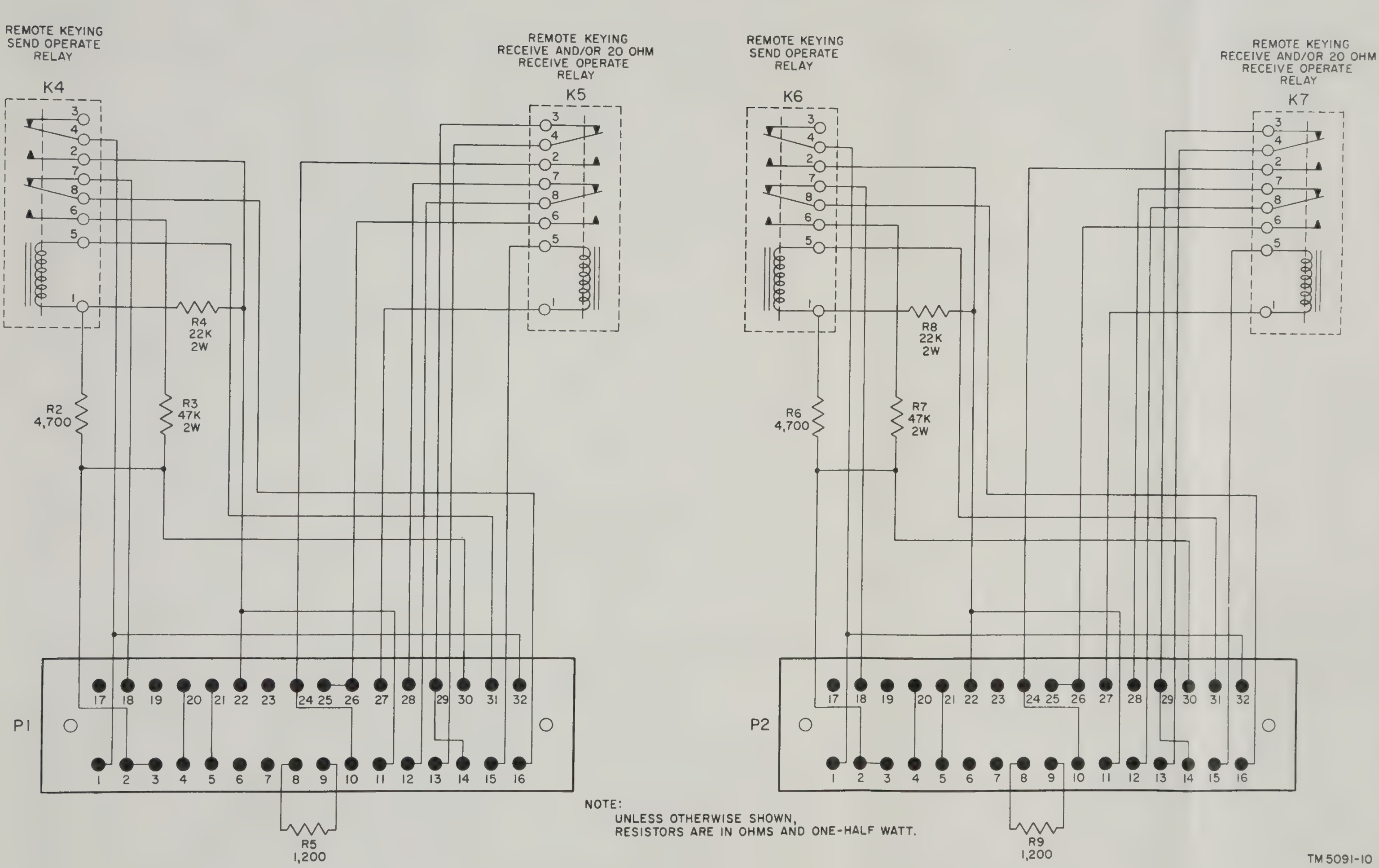
TM5091-9

Figure 264. Multiplexer Subassembly MX-1442/TC, over-all schematic diagram.


REMOTE KEYING SEND OPERATE RELAY
K4
3
4
2
7
8
6
5
1
R4 22K 2W
R2 4,700
R3 47K 2W
RE
RECEIVI
RECI
REMOTE KEYING RECEIVE AND/OR 20 OHM RECEIVE OPERATE RELAY
K7
3
4
2
7
8
6
5
1
P1
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
0
31
32
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
4
15
16
R5 1,200

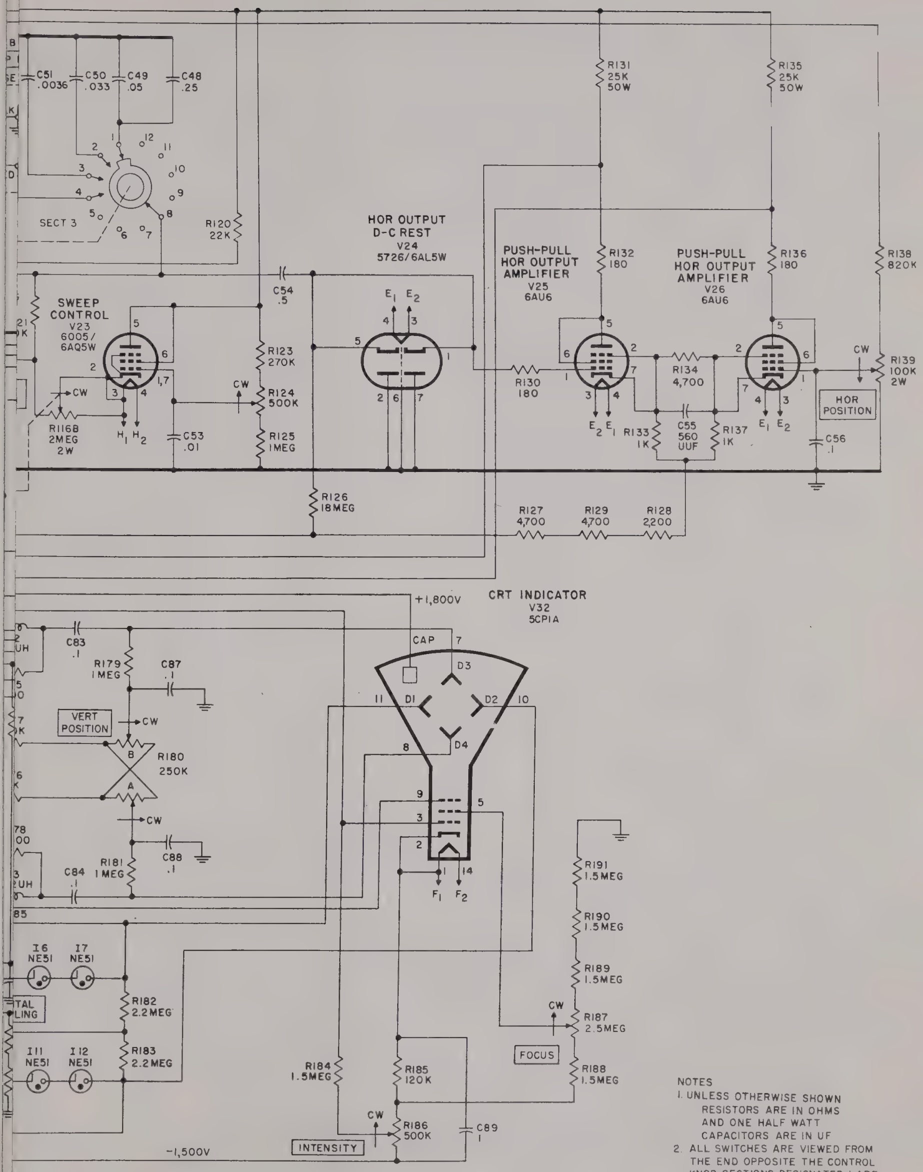
TM 5091-10

Figure 265. Remote Switching Control C–1509/TC, over-all schematic diagram.


REMOTE KEYING SEND OPERATE RELAY
K4
REMOTE KEYING RECEIVE AND/OR 20 OHM RECEIVE OPERATE RELAY
K5
REMOTE KEYING SEND OPERATE RELAY
K6
REMOTE KEYING RECEIVE AND/OR 20 OHM RECEIVE OPERATE RELAY
K7
R4 22K 2W
R2 4,700
R3 47K 2W
R8 22K 2W
R6 4,700
R7 47K 2W
P1
P2
R5 1,200
R9 1,200
TM 5091-10

NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS AND ONE-HALF WATT.

Figure 265. Remote Switching Control C–1509/TC, over-all schematic diagram.


C51
.0036
C50
.033
C49
.05
C48
.25
SECT 3
R120
22K
HOR OUTPUT
D-C REST
V24
5726/6AL5W
E1 E2
PUSH-PULL
HOR OUTPUT
AMPLIFIER
V25
6AU6
PUSH-PULL
HOR OUTPUT
AMPLIFIER
V26
6AU6
R131
25K
50W
R135
25K
50W
R132
180
R136
180
R138
820K
SWEEP
CONTROL
V23
6005/
6AQ5W
C54
.5
R123
270K
R124
500K
R125
1MEG
CW
R116B
2MEG
2W
H1 H2
C53
.01
R130
180
R134
4,700
R133
1K
C55
560
UUF
R137
1K
E2 E1
R139
100K
2W
HOR
POSITION
C56
.1
R126
18MEG
R127
4,700
R129
4,700
R128
2,200
+1,800V
CRT INDICATOR
V32
5CP1A
CAP
D1
D2
D3
D4
F1 F2
C83
.1
R179
1MEG
C87
.1
VERT
POSITION
R180
250K
R181
1MEG
C88
.1
C84
.1
I6
NE51
I7
NE51
I11
NE51
I12
NE51
R182
2.2MEG
R183
2.2MEG
R184
1.5MEG
R185
120K
R186
500K
C89
1
INTENSITY
-1,500V
R191
1.5MEG
R190
1.5MEG
R189
1.5MEG
R187
2.5MEG
R188
1.5MEG
FOCUS

NOTES
1. UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
AND ONE HALF WATT
CAPACITORS ARE IN UF
2. ALL SWITCHES ARE VIEWED FROM
THE END OPPOSITE THE CONTROL
KNOB. SECTIONS DESIGNATED I ARE
NEAREST THE KNOB END.

TM5091-11

Figure 266. Oscilloscope OS-25/G, over-all schematic diagram.

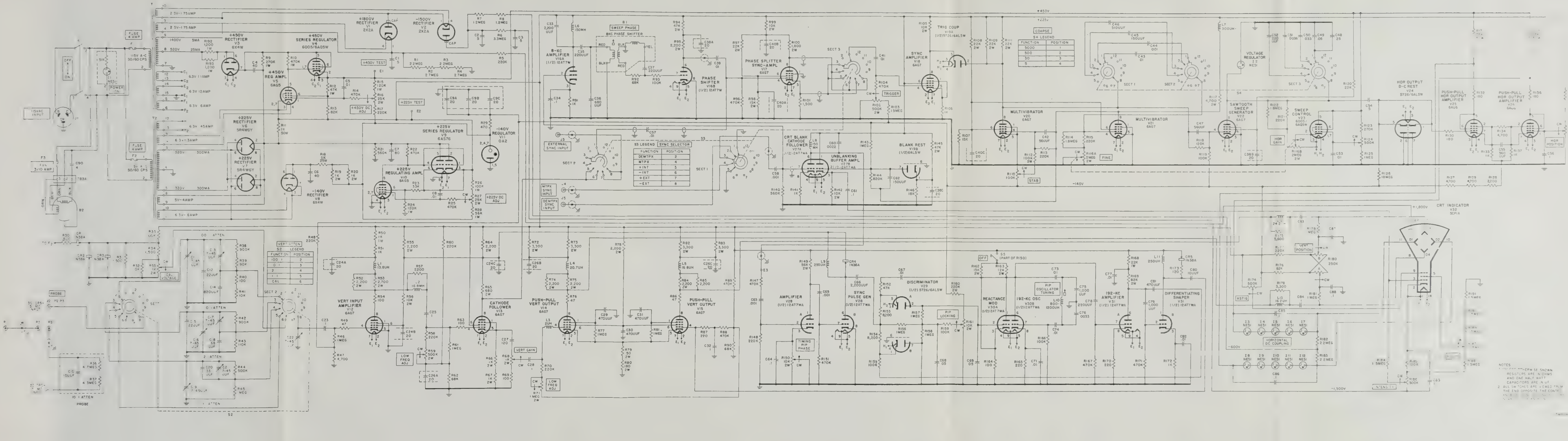
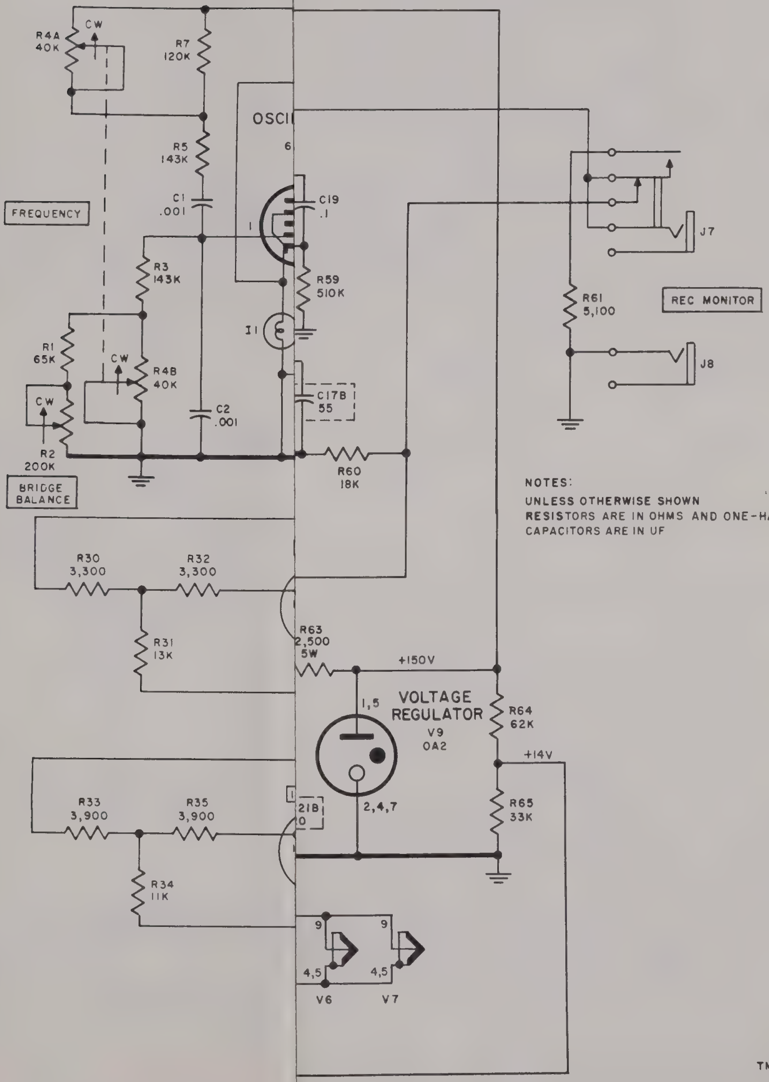

115VAC INPUT
POWER
+450V RECTIFIER V3 6X4W
+450V SERIES REGULATOR V4 6005/6AQ5W
+450V REG AMPL V5 6AQ5
+1800V RECTIFIER V1 2X2A
-1500V RECTIFIER V2 2X2A
+450V TEST
+450V DC ADJ
+225V TEST
+225V RECTIFIER V6 5R4WGY
+225V RECTIFIER V7 5R4WGY
+225V SERIES REGULATOR V9 6AS7G
+225V REGULATING AMPL V10 6AQ5
+225V DC ADJ
-140V RECTIFIER V8 6X4W
-140V REGULATOR V11 OA2
8-KC AMPLIFIER V16A (1/2) 12AT7W
SWEEP PHASE
8KC PHASE SHIFTER
PHASE SHIFTER V16B (1/2) 12AT7W
PHASE SPLITTER SYNC-AMPL V17 6AG7
SYNC AMPLIFIER V18 6AG7
TRIG COUP V19 (1/2)5726/6AL5W
TRIGGER
COARSE
S4 LEGEND
MULTIVIBRATOR V20 6AG7
MULTIVIBRATOR V21 6AG7
STAB
FINE
SAWTOOTH SWEEP GENERATOR V22 6AG7
SWEEP CONTROL V23 6AG7
VOLTAGE REGULATOR I2 NE51
HOR GAIN
HOR OUTPUT D-C REST V24 5726/6AL5W
PUSH-PULL HOR OUTPUT AMPLIFIER V25 6AU6
PUSH-PULL HOR OUTPUT AMPLIFIER V26 6AU6
HOR POSITION
EXTERNAL SYNC INPUT
S3 LEGEND
SYNC SELECTOR
MTPX SYNC INPUT
DEMTPX SYNC INPUT
CRT BLANK CATHODE FOLLOWER V27A (1/2) 12AT7WA
UNBLANKING BUFFER AMPL V27B (1/2) 12AT7WA
BLANK REST V19B (1/2)6AL5W
CRT INDICATOR V32 5CP1A
VERT POSITION
ASTIG
HORIZONTAL DC COUPLING
PROBE
VERT ATTEN S2 LEGEND
VERT INPUT AMPLIFIER V12 6AG7
LOW FREQ ADJ
CATHODE FOLLOWER V13 6AG7
VERT GAIN
PUSH-PULL VERT OUTPUT V14 6AG7
PUSH-PULL VERT OUTPUT V15 6AG7
AMPLIFIER V28 (1/2)12AT7WA
TIMING PIP PHASE
DISCRIMINATOR V29 (1/2) 5726/6AL5W
SYNC PULSE GEN V28 (1/2)12AT7WA
PIP LOCKING
REACTANCE MOD V30A (1/2)12AT7WA
192-KC OSC V30B (1/2)12AT7WA
PIP OSCILLATOR TUNING
192-KC AMPLIFIER V31 (1/2)12AT7WA
DIFFERENTIATING SHAPER V31 (1/2)12AT7WA
10:1 ATTEN
PROBE
NOTES
1. UNLESS OTHERWISE SHOWN RESISTORS ARE IN OHMS AND ONE HALF WATT CAPACITORS ARE IN UF
2. ALL SWITCHES ARE VIEWED FROM THE END OPPOSITE THE CONTR

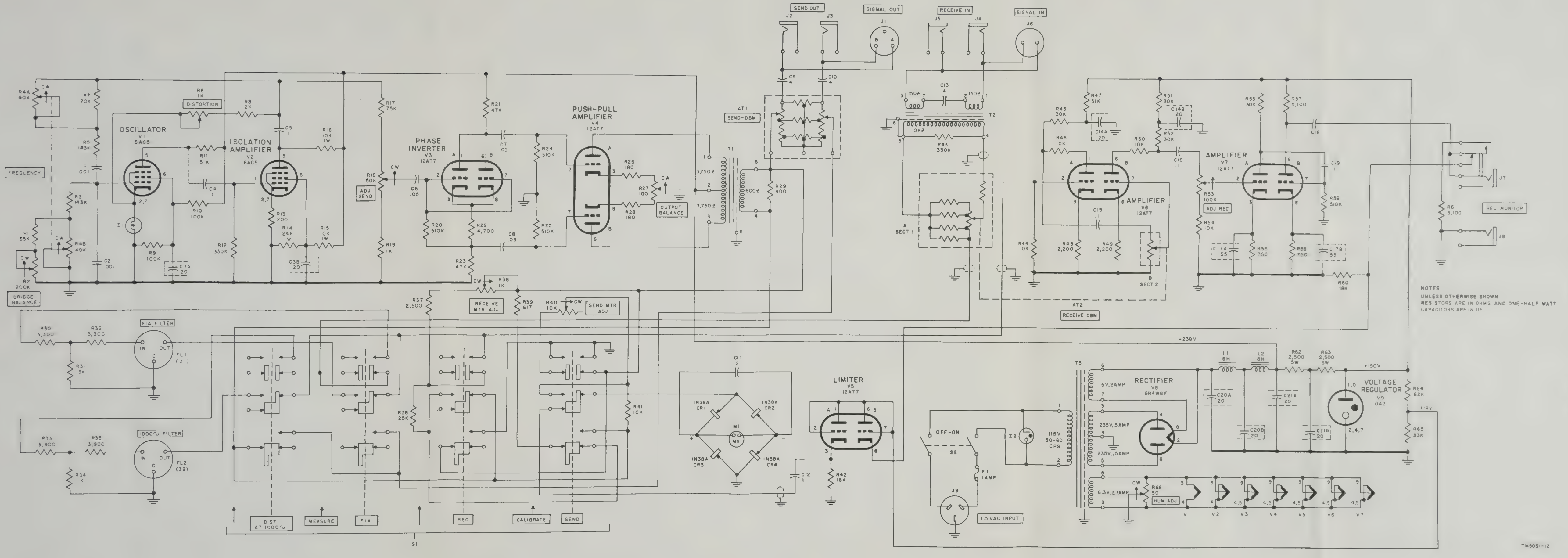
Figure 268. Oscilloscope OS-25/G, over-all schematic diagram.


R4A
40K
CW
R7
120K
OSCI
R5
143K
6
FREQUENCY
C1
.001
C19
.1
1
R3
143K
R59
510K
I1
R1
65K
CW
R4B
40K
CW
C17B
55
C2
.001
R2
200K
BRIDGE BALANCE
R60
18K
J7
REC MONITOR
R61
5,100
J8
R30
3,300
R32
3,300
R31
13K
R63
2,500
5W
+150V
VOLTAGE REGULATOR
V9
OA2
1,5
R64
62K
+14V
R33
3,900
R35
3,900
21B
0
2,4,7
R65
33K
R34
11K
9
9
4,5
4,5
V6
V7

NOTES:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS AND ONE-HALF WATT
CAPACITORS ARE IN UF

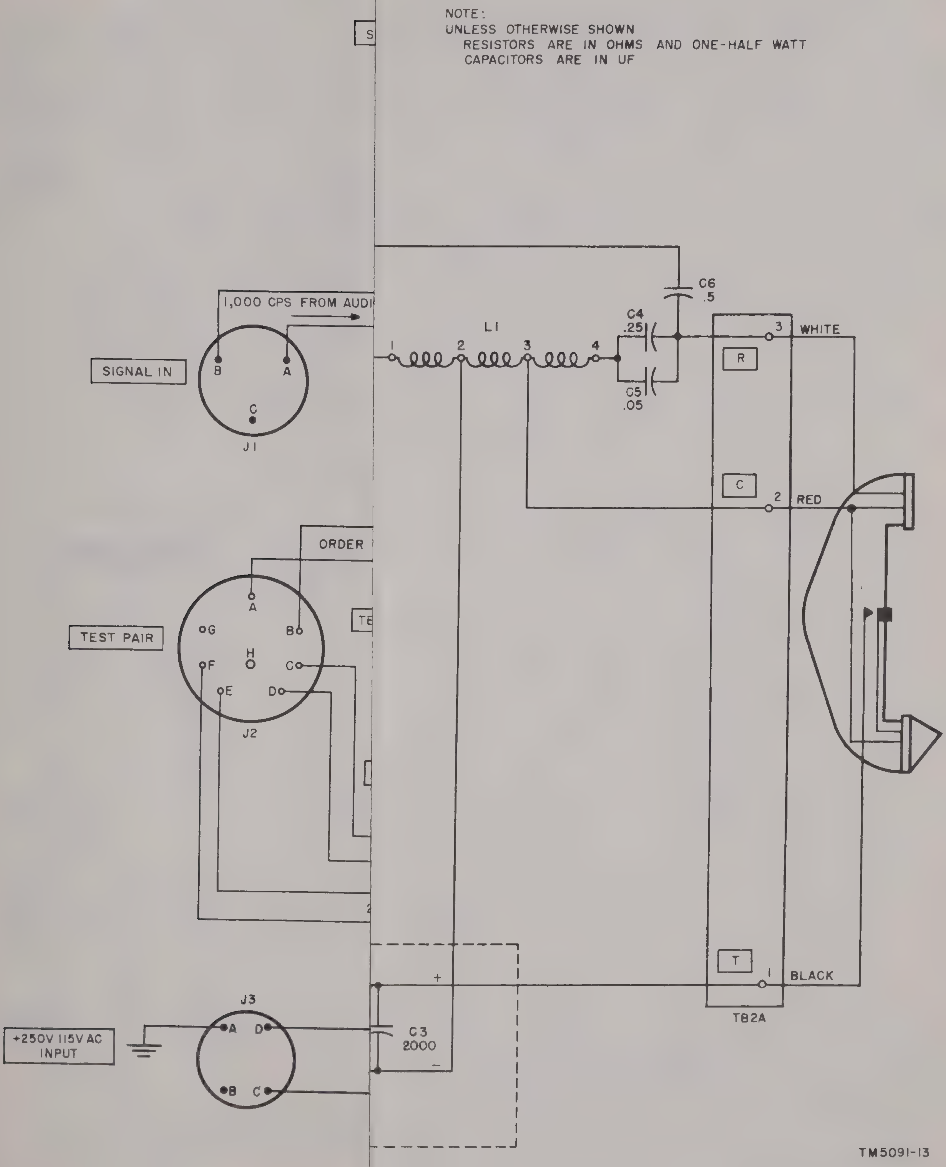
TM5091-12

Figure 267. Audio Test Set TS-762/TC, over-all schematic diagram.


OSCILLATOR
V1 6AG5
ISOLATION AMPLIFIER
V2 6AG5
PHASE INVERTER
V3 12AT7
PUSH-PULL AMPLIFIER
V4 12AT7
FREQUENCY
DISTORTION
BRIDGE BALANCE
ADJ SEND
OUTPUT BALANCE
RECEIVE MTR ADJ
SEND MTR ADJ
FIA FILTER
1000~ FILTER
FL1 (Z1)
FL2 (Z2)
SEND OUT
SIGNAL OUT
RECEIVE IN
SIGNAL IN
J1
J2
J3
J4
J5
J6
J7
J8
AT1
SEND-DBM
AT2
RECEIVE DBM
T1
T2
T3
AMPLIFIER
V6 12AT7
AMPLIFIER
V7 12AT7
ADJ REC
REC MONITOR
LIMITER
V5 12AT7
M1 MA
RECTIFIER
V8 5R4WGY
VOLTAGE REGULATOR
V9 0A2
OFF-ON
S2
F1 1AMP
115V 50-60 CPS
115VAC INPUT
HUM ADJ
+238V
+150V
DST AT 1000~
MEASURE
FIA
REC
CALIBRATE
SEND
S1
TM5091-12

NOTES
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS AND ONE-HALF WATT
CAPACITORS ARE IN UF

Figure 267. Audio Test Set TS-762/TC, over-all schematic diagram.


S
1,000 CPS FROM AUDI
SIGNAL IN
B
A
C
J1
ORDER
TEST PAIR
A
G
B
H
F
C
E
D
J2
TE
2
J3
+250V 115V AC INPUT
A
D
B
C
C3
2000
+
−
L1
1
2
3
4
C4
.25
C5
.05
C6
.5
R
C
T
3
WHITE
2
RED
1
BLACK
TB2A

NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS AND ONE-HALF WATT
CAPACITORS ARE IN UF

TM5091-13

Figure 268. Control Monitor C–1151/TC, over-all schematic diagram.

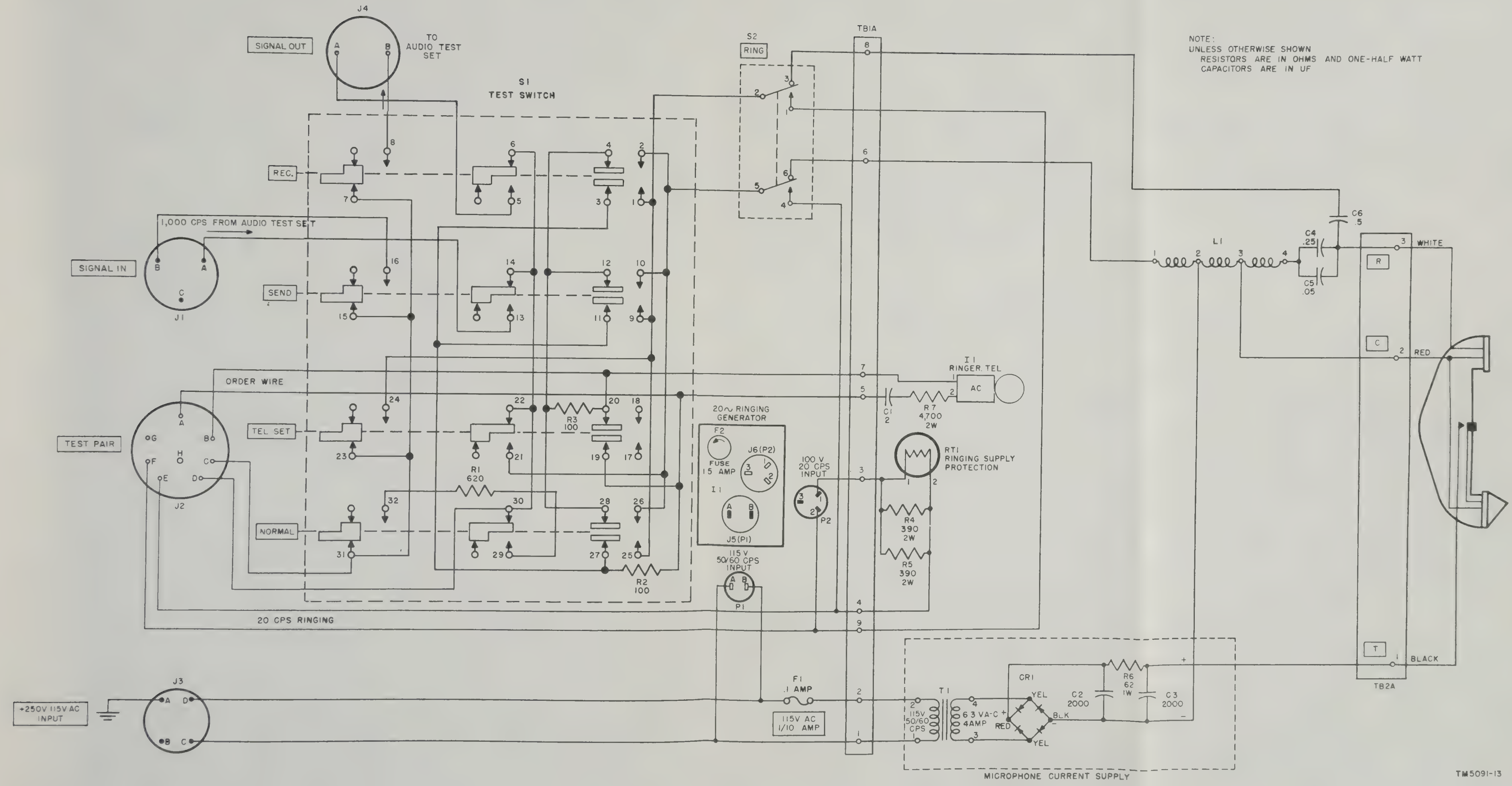
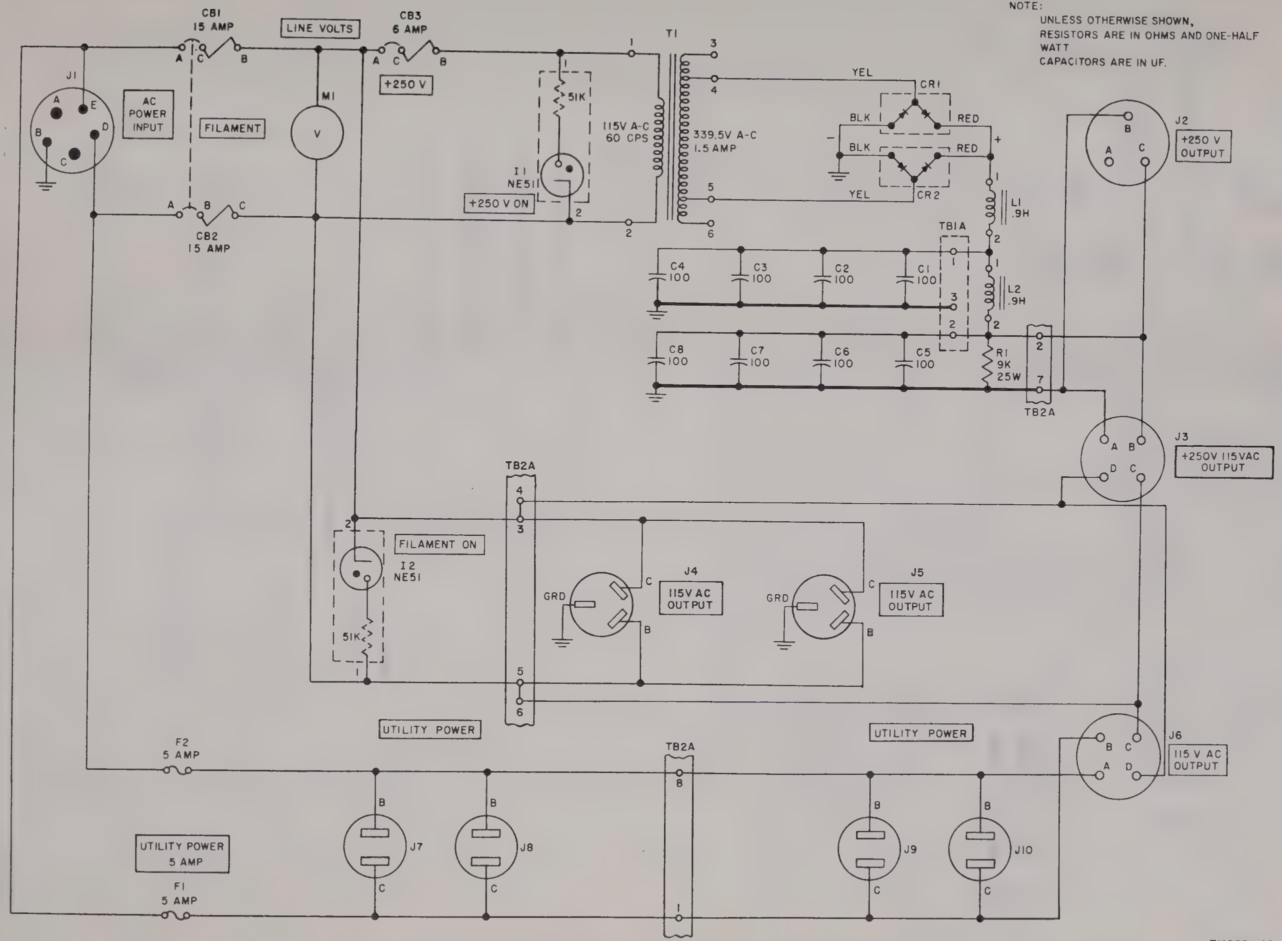

J4
SIGNAL OUT
TO AUDIO TEST SET
S1
TEST SWITCH
S2
RING
TB1A
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS AND ONE-HALF WATT
CAPACITORS ARE IN UF
REC.
1,000 CPS FROM AUDIO TEST SET
SIGNAL IN
J1
SEND
L1
C6 .5
C4 .25
C5 .05
WHITE
R
C
RED
ORDER WIRE
TEST PAIR
J2
TEL. SET
NORMAL
R3 100
R1 620
R2 100
I 1
RINGER TEL
AC
C1 2
R7 4,700 2W
20∼ RINGING GENERATOR
F2
FUSE 1.5 AMP
J6(P2)
J5(P1)
100 V 20 CPS INPUT
P2
RT1
RINGING SUPPLY PROTECTION
R4 390 2W
R5 390 2W
115 V 50/60 CPS INPUT
P1
20 CPS RINGING
J3
+250V 115V AC INPUT
F1
.1 AMP
115V AC 1/10 AMP
T1
115V 50/60 CPS
6.3 VA-C 4AMP
CR1
YEL
BLK
RED
C2 2000
R6 62 1W
C3 2000
T
BLACK
TB2A
MICROPHONE CURRENT SUPPLY
TM5091-13

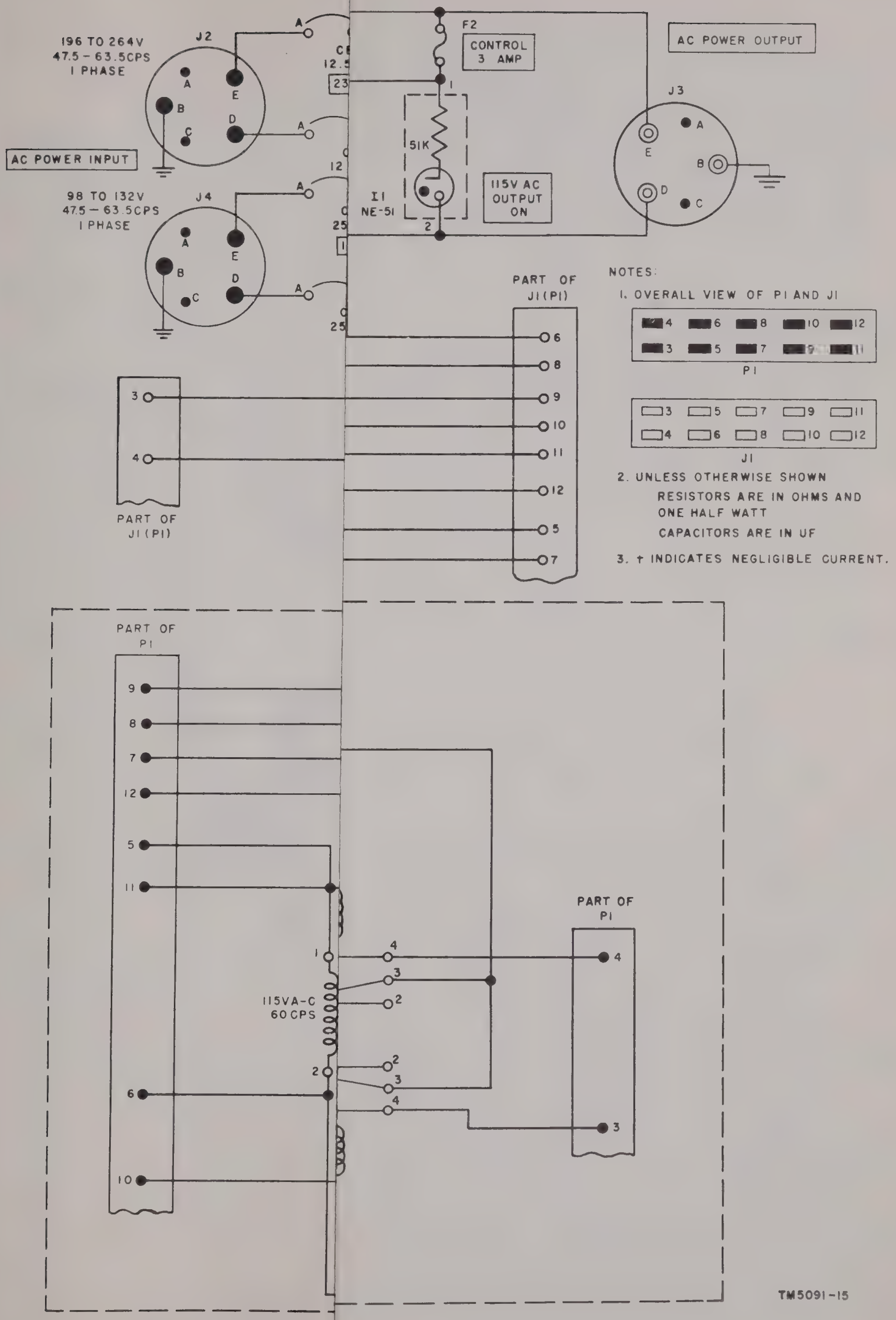
Figure 268. *Control Monitor C–1151/TC, over-all schematic diagram.*


CB1
15 AMP
LINE VOLTS
CB3
6 AMP
T1
J1
AC POWER INPUT
FILAMENT
M1
V
+250 V
51K
115V A-C
60 CPS
339.5V A-C
1.5 AMP
I1
NE51
+250 V ON
CB2
15 AMP
YEL
CR1
BLK
RED
CR2
J2
+250 V OUTPUT
L1
.9H
L2
.9H
TB1A
C1 100
C2 100
C3 100
C4 100
C5 100
C6 100
C7 100
C8 100
R1
9K
25W
TB2A
J3
+250V 115VAC OUTPUT
FILAMENT ON
I2
NE51
51K
J4
115V AC OUTPUT
J5
115V AC OUTPUT
GRD
UTILITY POWER
J6
115 V AC OUTPUT
F2
5 AMP
UTILITY POWER
5 AMP
F1
5 AMP
J7
J8
J9
J10

NOTE:
UNLESS OTHERWISE SHOWN,
RESISTORS ARE IN OHMS AND ONE-HALF WATT
CAPACITORS ARE IN UF.

TM5091-14

Figure 269. Power Supply PP–691/G, over-all schematic diagram.


196 TO 264V
47.5 - 63.5CPS
1 PHASE
J2
A
B
C
D
E
AC POWER INPUT
98 TO 132V
47.5 - 63.5CPS
1 PHASE
J4
F2
CONTROL
3 AMP
51K
I1
NE-51
115V AC
OUTPUT
ON
AC POWER OUTPUT
J3
PART OF
J1(P1)
PART OF
P1
115VA-C
60CPS
P1
J1
TM5091-15

NOTES:

1. OVERALL VIEW OF P1 AND J1

2. UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS AND ONE HALF WATT
CAPACITORS ARE IN UF

3. † INDICATES NEGLIGIBLE CURRENT.

Figure 270. Voltage Regulator CN-236/G, over-all schematic diagram.

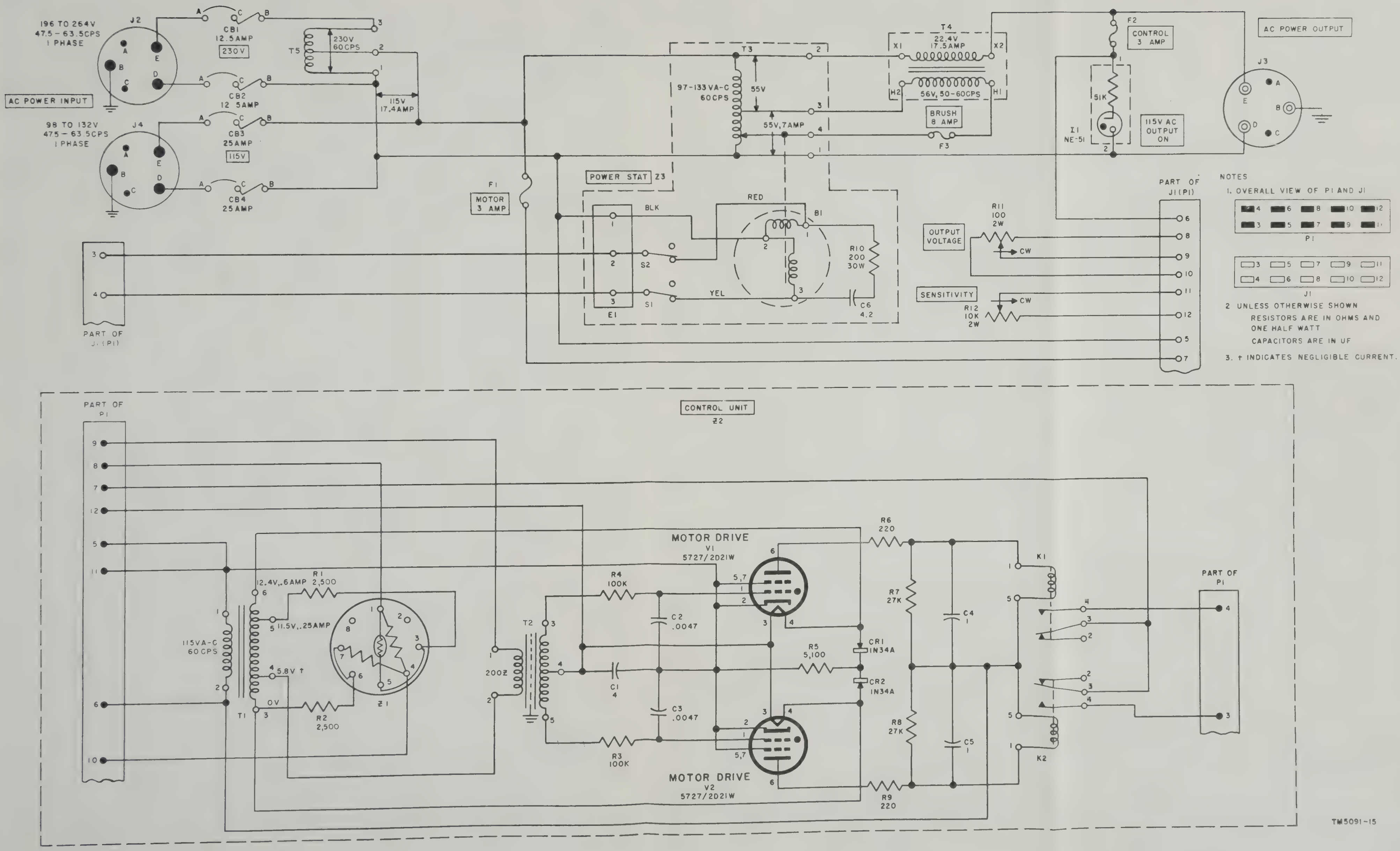

196 TO 264V
47.5 - 63.5CPS
1 PHASE
J2
AC POWER INPUT
98 TO 132V
47.5 - 63.5CPS
1 PHASE
J4
CB1
12.5AMP
230V
CB2
12.5AMP
CB3
25AMP
115V
CB4
25AMP
T5
230V
60CPS
115V
17.4AMP
F1
MOTOR
3 AMP
T3
97-133 VA-C
60CPS
55V
55V,7AMP
POWER STAT Z3
T4
22.4V
17.5AMP
X1
X2
H2
H1
56V, 50-60CPS
BRUSH
8 AMP
F3
F2
CONTROL
3 AMP
51K
I1
NE-51
115V AC
OUTPUT
ON
AC POWER OUTPUT
J3
BLK
RED
YEL
B1
E1
S1
S2
R10
200
30W
C6
4.2
PART OF
J1 (P1)
OUTPUT
VOLTAGE
R11
100
2W
CW
SENSITIVITY
R12
10K
2W
PART OF
J1 (P1)
NOTES
1. OVERALL VIEW OF P1 AND J1
P1
J1
2 UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS AND
ONE HALF WATT
CAPACITORS ARE IN UF
3. † INDICATES NEGLIGIBLE CURRENT.
CONTROL UNIT
Z2
PART OF
P1
115VA-C
60CPS
T1
12.4V, .6AMP
11.5V, .25AMP
5.8V †
0V
R1
2,500
R2
2,500
Z1
200Z
T2
R4
100K
C2
.0047
C1
4
C3
.0047
R3
100K
MOTOR DRIVE
V1
5727/2D21W
MOTOR DRIVE
V2
5727/2D21W
R5
5,100
CR1
1N34A
CR2
1N34A
R6
220
R7
27K
R8
27K
R9
220
C4
1
C5
1
K1
K2
PART OF
P1
TM5091-15

Figure 270. Voltage Regulator CN-236/G, over-all schematic diagram.

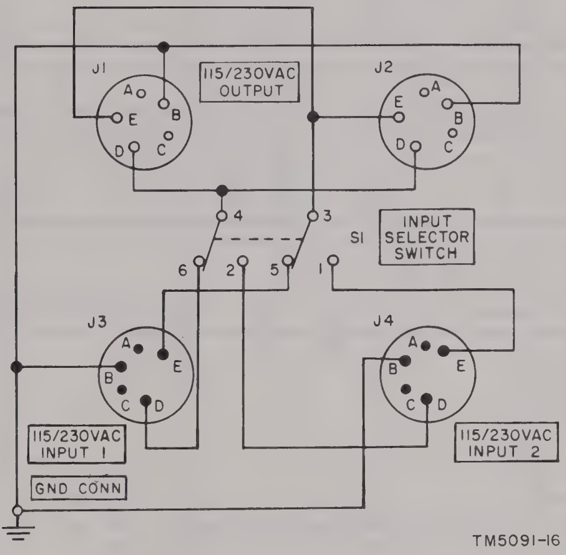

J1
115/230VAC OUTPUT
J2
A
B
C
D
E
4
3
S1
INPUT SELECTOR SWITCH
6
2
5
1
J3
J4
115/230VAC INPUT 1
GND CONN
115/230VAC INPUT 2
TM5091-16

Figure 271. Switch Box SA–357/G, over-all schematic diagram.

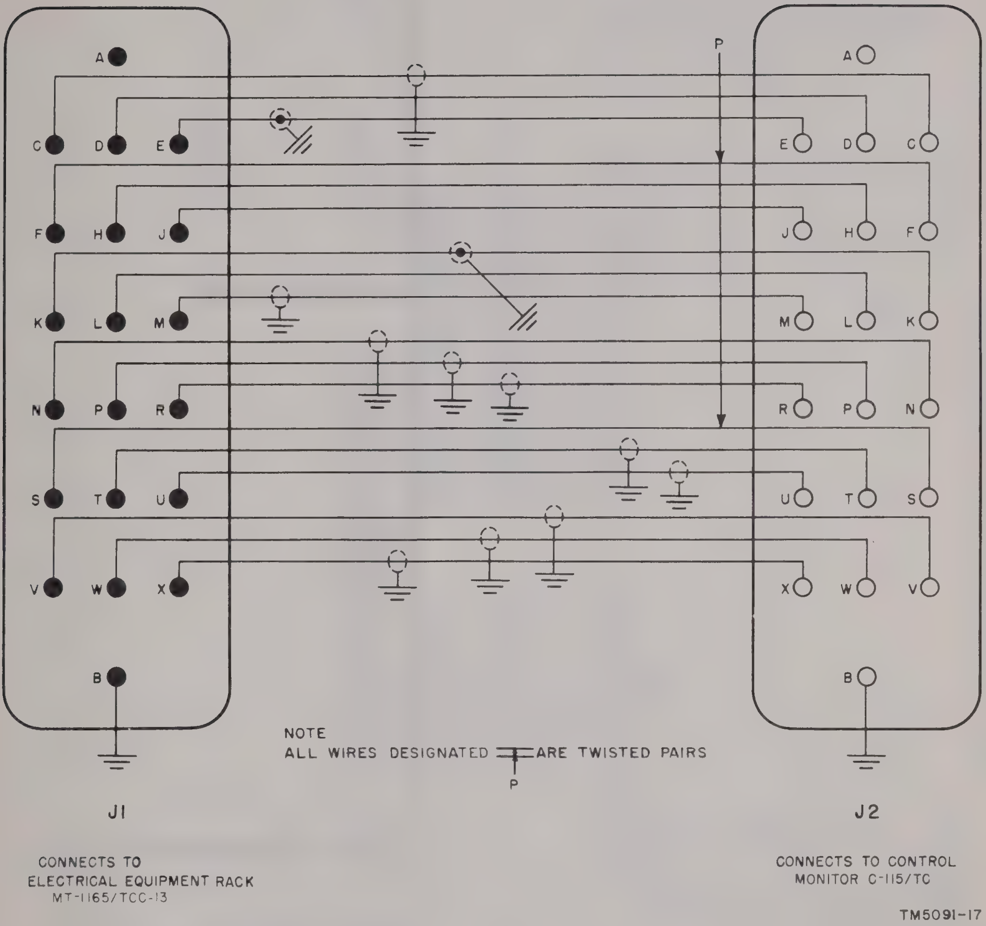

A
C
D
E
F
H
J
K
L
M
N
P
R
S
T
U
V
W
X
B
P
NOTE
ALL WIRES DESIGNATED ARE TWISTED PAIRS
P
J1
CONNECTS TO
ELECTRICAL EQUIPMENT RACK
MT-1165/TCC-13
J2
CONNECTS TO CONTROL
MONITOR C-115/TC
TM5091-17

Figure 272. Electrical Connector Assembly J–535/G, over-all schematic diagram.

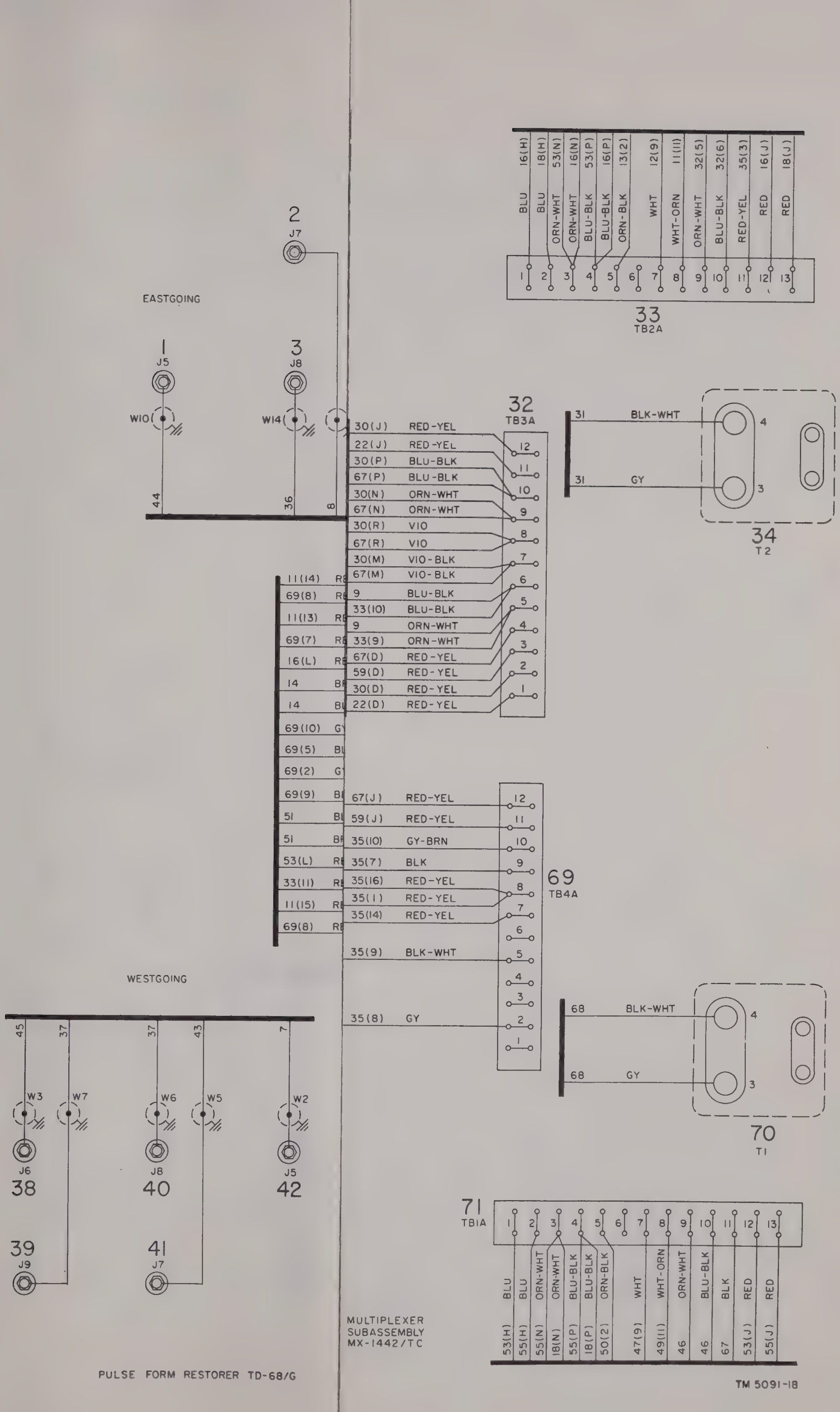

EASTGOING
WESTGOING
PULSE FORM RESTORER TD-68/G
MULTIPLEXER SUBASSEMBLY MX-1442/TC
1 J5
2 J7
3 J8
W10
W14
44
36
8
38 J6
40 J8
42 J5
39 J9
41 J7
W3
W7
W6
W5
W2
45
37
37
43
7
32 TB3A
33 TB2A
34 T2
69 TB4A
70 T1
71 TB1A
31 BLK-WHT
31 GY
68 BLK-WHT
68 GY
30(J) RED-YEL
22(J) RED-YEL
30(P) BLU-BLK
67(P) BLU-BLK
30(N) ORN-WHT
67(N) ORN-WHT
30(R) VIO
67(R) VIO
30(M) VIO-BLK
67(M) VIO-BLK
9 BLU-BLK
33(10) BLU-BLK
9 ORN-WHT
33(9) ORN-WHT
67(D) RED-YEL
59(D) RED-YEL
30(D) RED-YEL
22(D) RED-YEL
67(J) RED-YEL
59(J) RED-YEL
35(10) GY-BRN
35(7) BLK
35(16) RED-YEL
35(1) RED-YEL
35(14) RED-YEL
35(9) BLK-WHT
35(8) GY
11(14)
69(8)
11(13)
69(7)
16(L)
14
14
69(10)
69(5)
69(2)
69(9)
51
51
53(L)
33(11)
11(15)
69(8)
BLU 16(H)
BLU 18(H)
ORN-WHT 53(N)
ORN-WHT 16(N)
BLU-BLK 53(P)
BLU-BLK 16(P)
ORN-BLK 13(2)
WHT 12(9)
WHT-ORN 11(11)
ORN-WHT 32(5)
BLU-BLK 32(6)
RED-YEL 35(3)
RED 16(J)
RED 18(J)
53(H) BLU
55(H) BLU
55(N) ORN-WHT
18(N) ORN-WHT
55(P) BLU-BLK
18(P) BLU-BLK
50(2) ORN-BLK
47(9) WHT
49(11) WHT-ORN
46 ORN-WHT
46 BLU-BLK
67 BLK
53(J) RED
55(J) RED
1 2 3 4 5 6 7 8 9 10 11 12 13
12 11 10 9 8 7 6 5 4 3 2 1
4
3
TM 5091-18

Figure 273. Multiplexer rack, over-all wiring diagram.

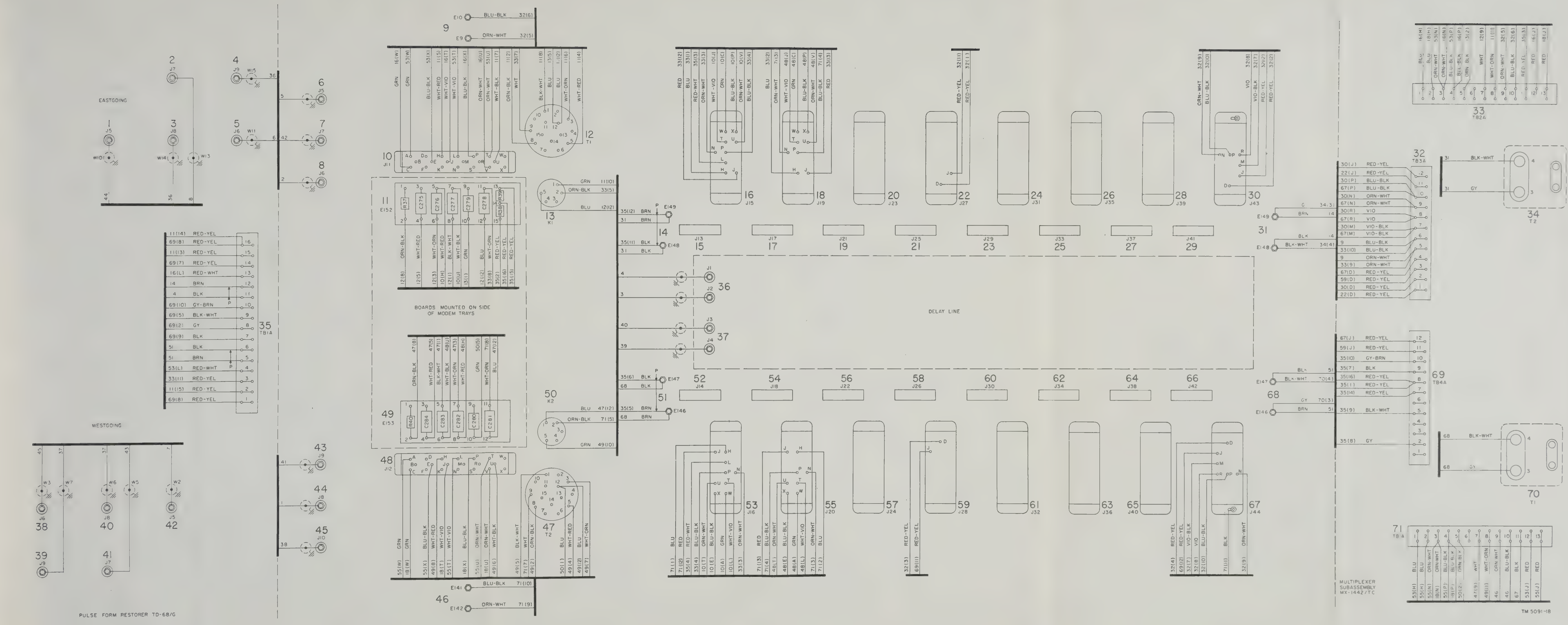

EASTGOING
WESTGOING
PULSE FORM RESTORER TD-68/G
35 TB1A
BOARDS MOUNTED ON SIDE OF MODEM TRAYS
11 E152
49 E153
10 J11
48 J12
12 T1
47 T2
13 K1
50 K2
14
51
9
46
E10 BLU-BLK 32(6)
E9 ORN-WHT 32(5)
E141 BLU-BLK 71(10)
E142 ORN-WHT 71(9)
36
37
DELAY LINE
16 J15
18 J19
20 J23
22 J27
24 J31
26 J35
28 J39
30 J43
15 J13
17 J17
19 J21
21 J25
23 J29
25 J33
27 J37
29 J41
52 J14
54 J18
56 J22
58 J26
60 J30
62 J34
64 J38
66 J42
53 J16
55 J20
57 J24
59 J28
61 J32
63 J36
65 J40
67 J44
31
68
E149
E148
E147
E146
32 TB3A
33 TB2A
34 T2
69 TB4A
70 T1
71 TB4A
MULTIPLEXER SUBASSEMBLY MX-1442/TC
TM 5091-18

Figure 273. Multiplexer rack, over-all wiring diagram.

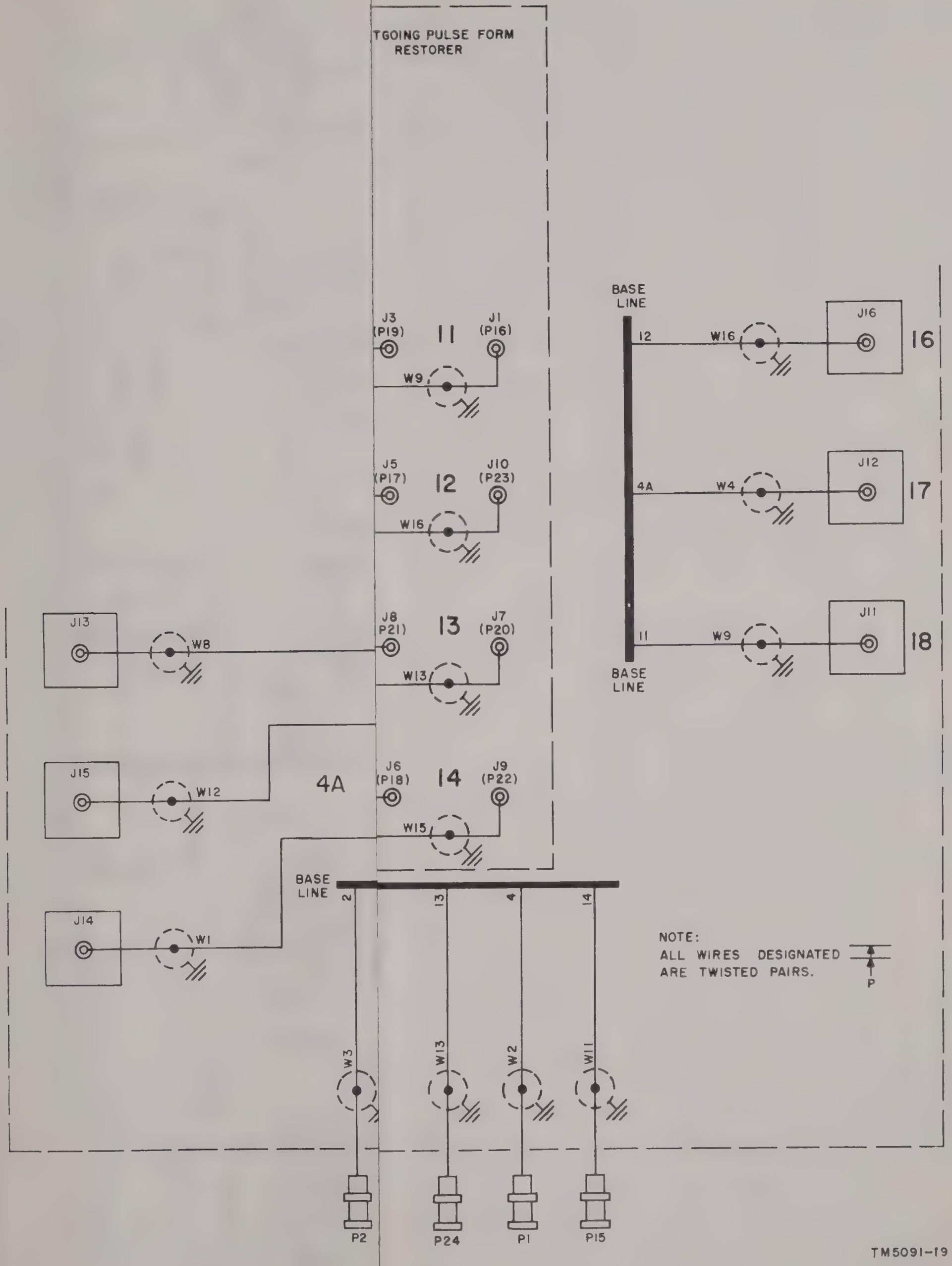
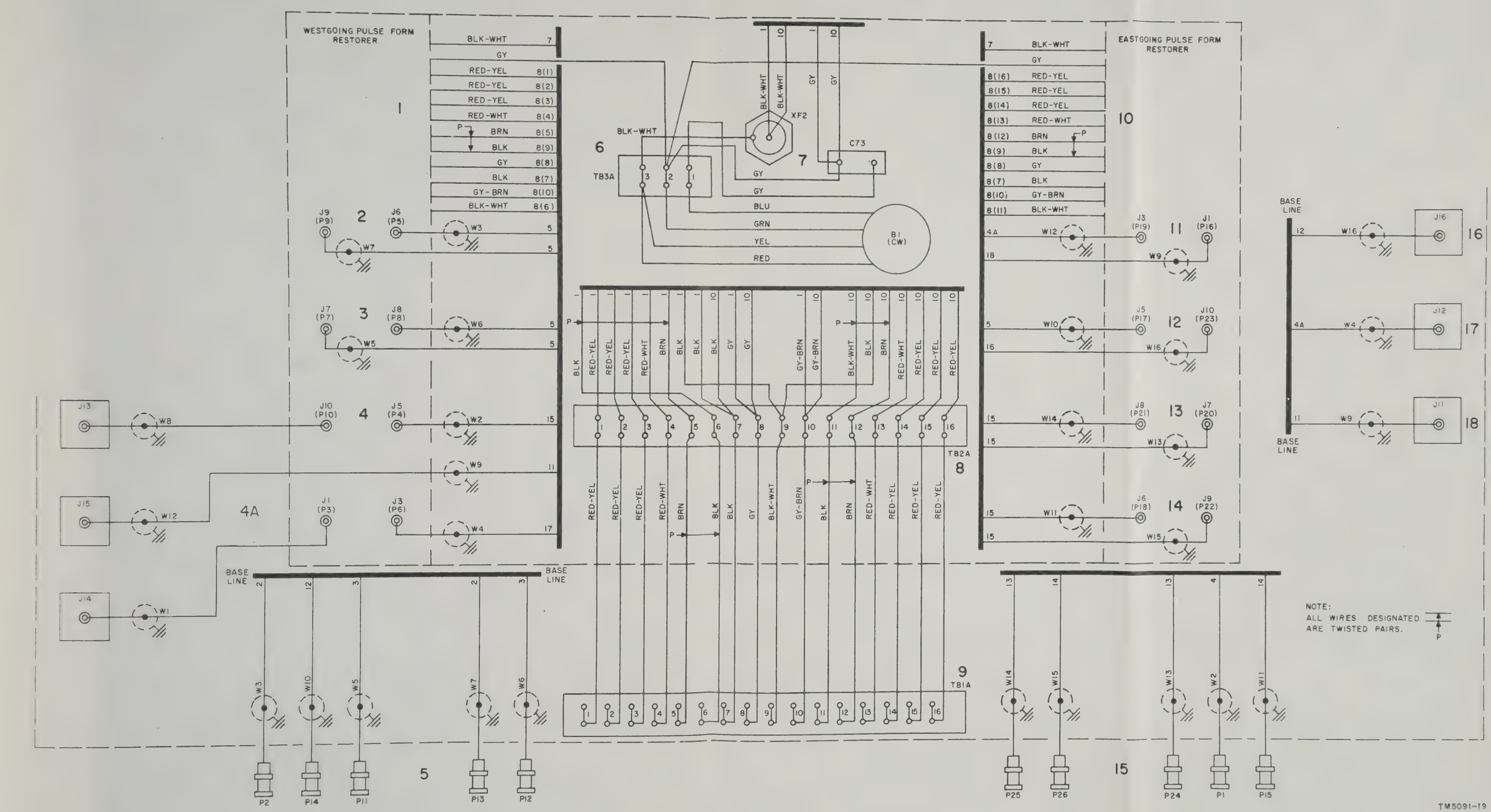
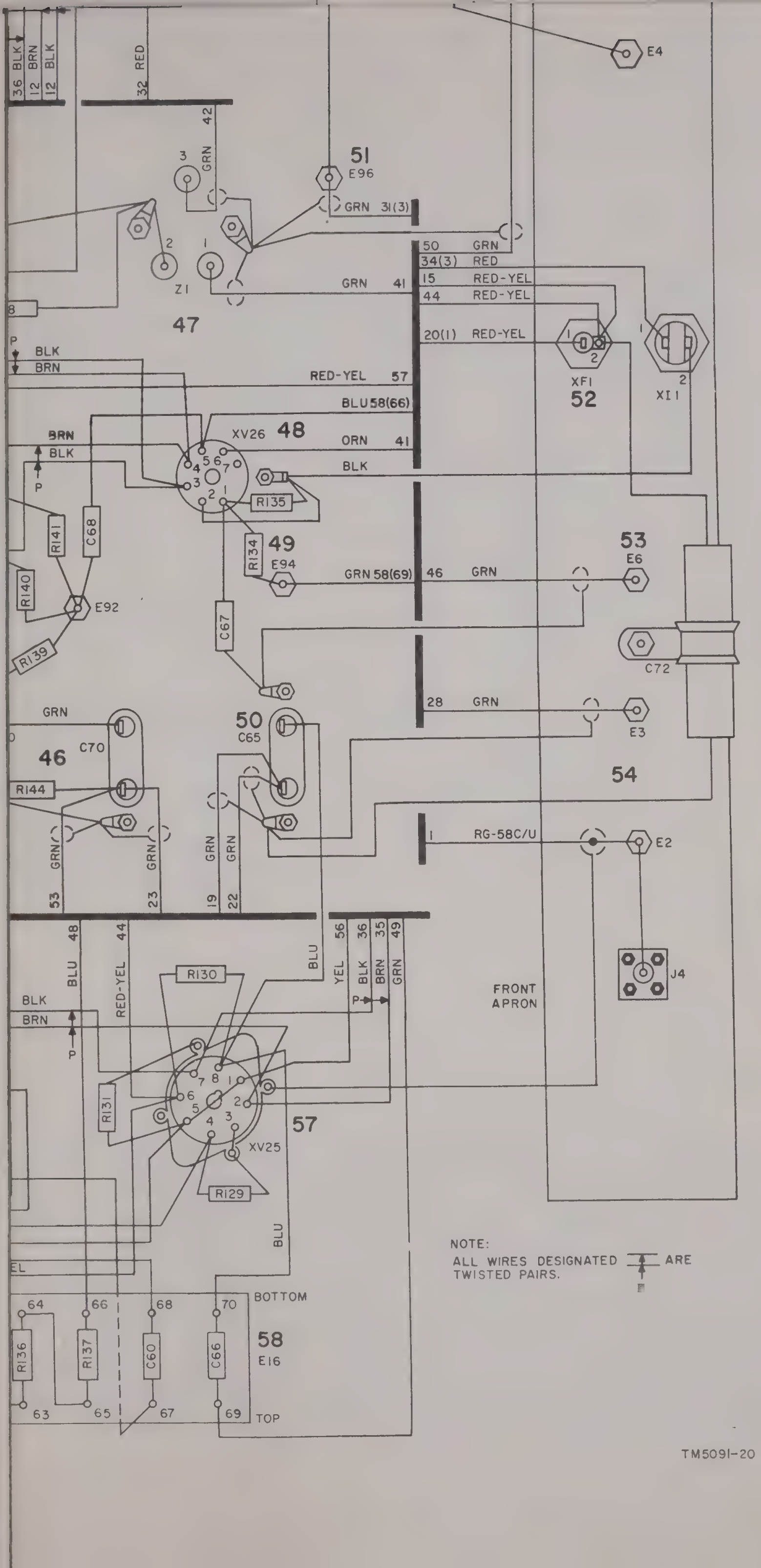

TGOING PULSE FORM
RESTORER
J3
(P19)
11
J1
(P16)
W9
J5
(P17)
12
J10
(P23)
W16
J8
(P21)
13
J7
(P20)
W13
J6
(P18)
14
J9
(P22)
W15
4A
J13
W8
J15
W12
J14
W1
BASE
LINE
2
13
4
14
W3
W13
W2
W11
P2
P24
P1
P15
BASE
LINE
12
W16
J16
16
4A
W4
J12
17
11
W9
J11
18
BASE
LINE
NOTE:
ALL WIRES DESIGNATED
ARE TWISTED PAIRS.
P
TM5091-19

Figure 274. Pulse Form Restorer TD-68/G, over-all wiring diagram.


WESTGOING PULSE FORM RESTORER
EASTGOING PULSE FORM RESTORER
TB3A
TB2A
TB1A
XF2
C73
B1 (CW)
BASE LINE
BLK-WHT
GY
RED-YEL
RED-WHT
BRN
BLK
GY-BRN
BLU
GRN
YEL
RED
J1 (P3)
J3 (P6)
J5 (P4)
J6 (P5)
J7 (P7)
J8 (P8)
J9 (P9)
J10 (P10)
J13
J14
J15
J1 (P16)
J3 (P19)
J5 (P17)
J10 (P23)
J8 (P21)
J7 (P20)
J6 (P18)
J9 (P22)
J16
J12
J11
W1
W2
W3
W4
W5
W6
W7
W8
W9
W10
W11
W12
W13
W14
W15
W16
P2
P14
P11
P13
P12
P25
P26
P24
P1
P15
1
2
3
4
4A
5
6
7
8
9
10
11
12
13
14
15
16
17
18
NOTE:
ALL WIRES DESIGNATED P ARE TWISTED PAIRS.

TM5091-19

Figure 274. Pulse Form Restorer TD-68/G, over-all wiring diagram.



E4
36 BLK
12 BRN
12 BLK
32 RED
42 GRN
51
E96
GRN 31(3)
Z1
47
50 GRN
34(3) RED
15 RED-YEL
44 RED-YEL
GRN 41
20(1) RED-YEL
XF1
52
XI1
P
BLK
BRN
RED-YEL 57
BLU 58(66)
XV26
48
ORN 41
BLK
R135
R141
C68
R140
R134
49
E94
GRN 58(69)
46 GRN
53
E6
E92
R139
C67
C72
GRN
C70
46
50
C65
28 GRN
E3
54
R144
GRN
53
23
19
22
1 RG-58C/U
E2
48 BLU
44 RED-YEL
BLU
56 YEL
36 BLK
35 BRN
49 GRN
J4
FRONT APRON
R130
R131
57
XV25
R129
BLU
NOTE:
ALL WIRES DESIGNATED ARE TWISTED PAIRS.
EL
64
66
68
70
BOTTOM
R136
R137
C60
C66
58
E16
63
65
67
69
TOP
TM5091-20

Figure 275. Video restorer, over-all wiring diagram.

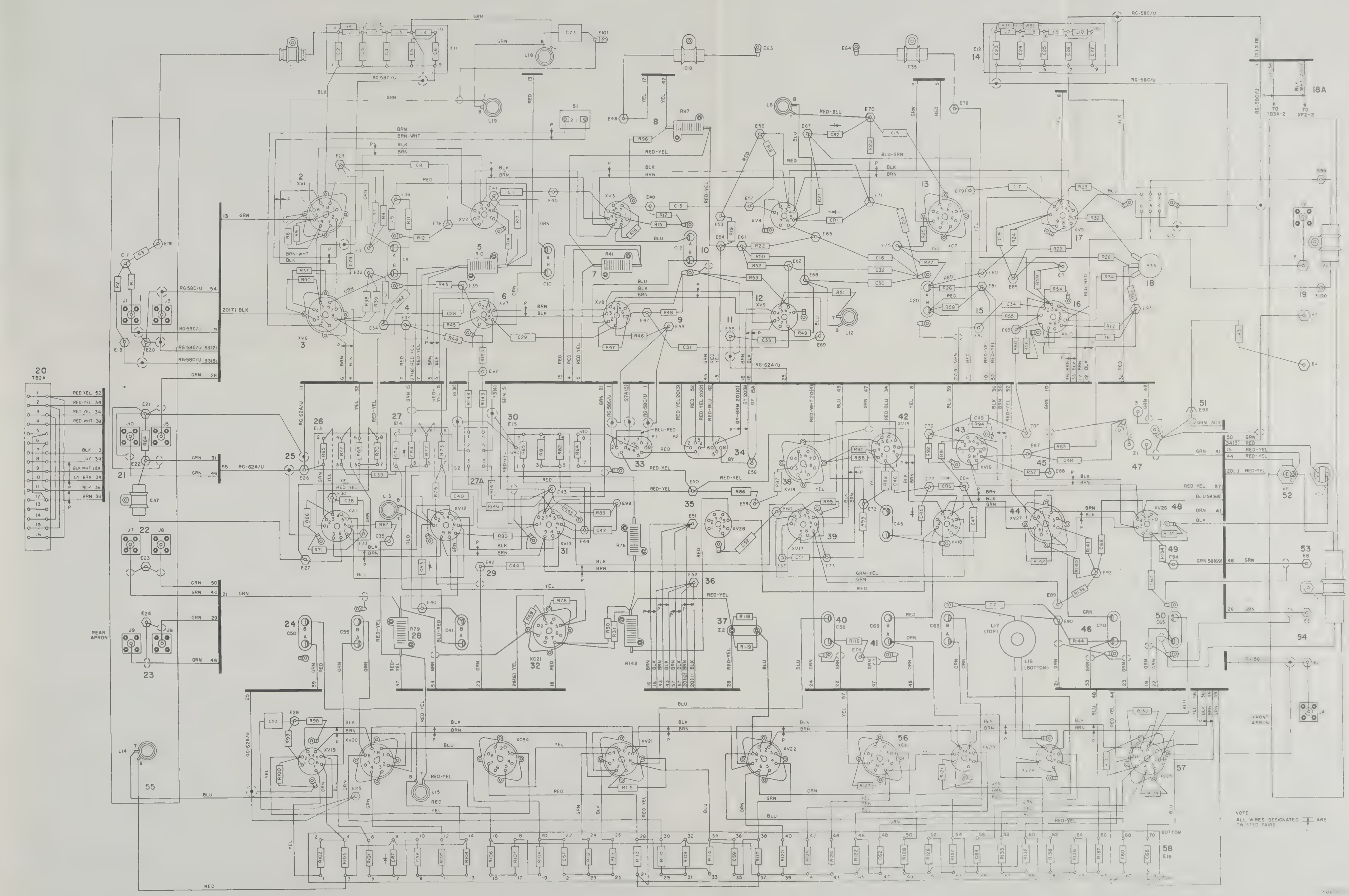

20
TB2A
REAR APRON
FRONT APRON
18A
BOTTOM
58
E16
L17 (TOP)
L16 (BOTTOM)
NOTE
ALL WIRES DESIGNATED ⌶ ARE TWISTED PAIRS

Figure 275. Video restorer, over-all wiring diagram.

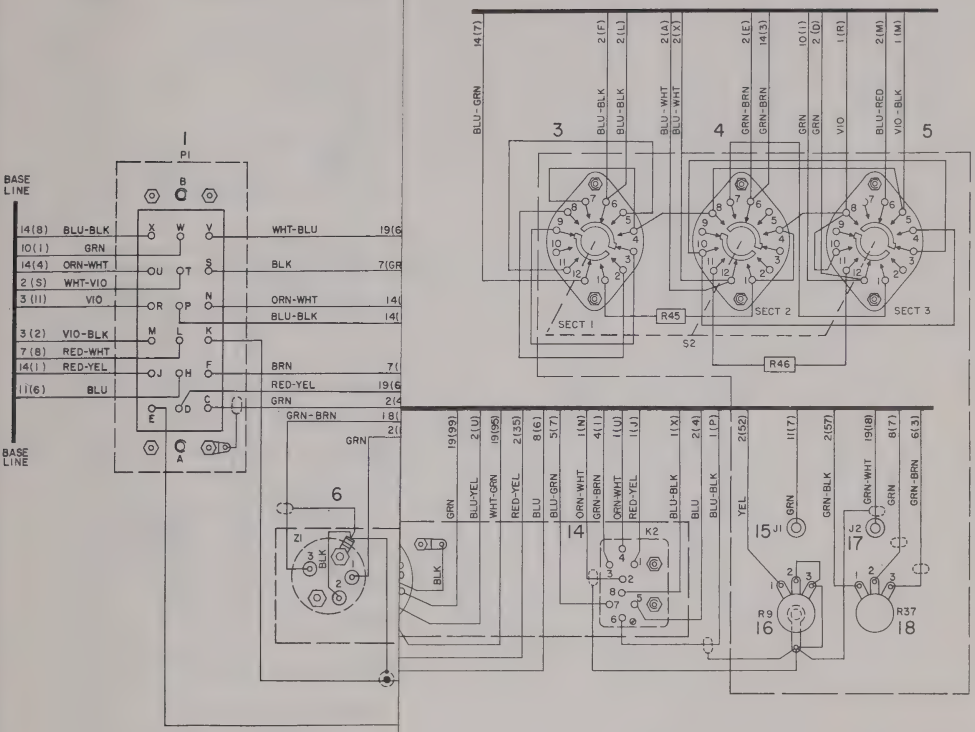
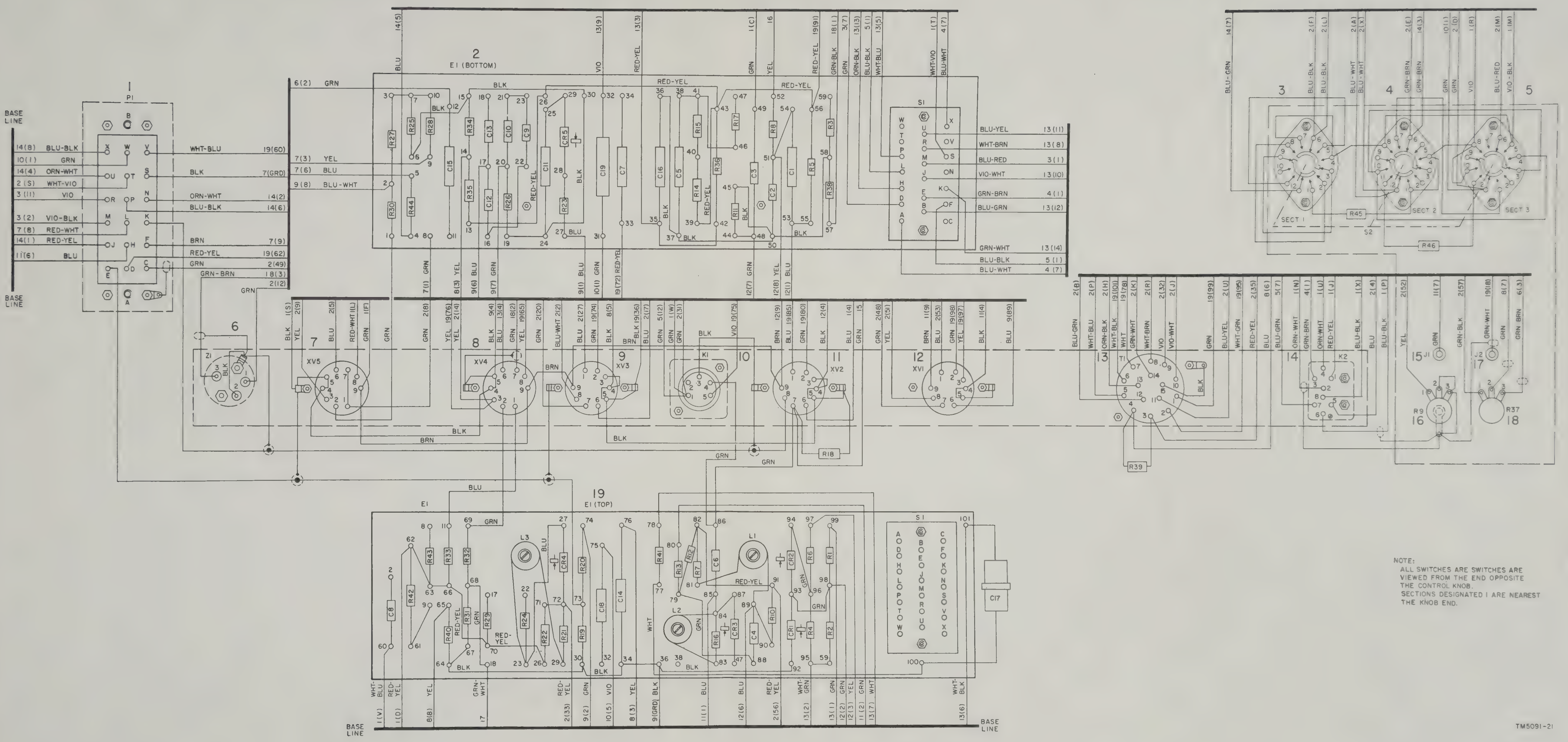

BASE LINE
1
P1
B
A
X
W
V
U
T
S
R
P
N
M
L
K
J
H
F
E
D
C
14(8) BLU-BLK
10(1) GRN
14(4) ORN-WHT
2(S) WHT-VIO
3(11) VIO
3(2) VIO-BLK
7(8) RED-WHT
14(1) RED-YEL
11(6) BLU
WHT-BLU
BLK
ORN-WHT
BLU-BLK
BRN
RED-YEL
GRN
GRN-BRN
GRN
3
4
5
SECT 1
SECT 2
SECT 3
S2
R45
R46
14(7) BLU-GRN
2(F) BLU-BLK
2(L) BLU-BLK
2(A) BLU-WHT
2(X) BLU-WHT
2(E) GRN-BRN
14(3) GRN-BRN
10(1) GRN
2(D) GRN
1(R) VIO
2(M) BLU-RED
1(M) VIO-BLK
6
Z1
BLK
19(99) GRN
2(U) BLU-YEL
19(95) WHT-GRN
2(35) RED-YEL
8(6) BLU
5(7) BLU-GRN
1(N) ORN-WHT
4(1) GRN-BRN
1(U) ORN-WHT
1(J) RED-YEL
1(X) BLU-BLK
2(4) BLU
1(P) BLU-BLK
2(52) YEL
11(7) GRN
2(57) GRN-BLK
19(18) GRN-WHT
8(7) GRN
6(3) GRN-BRN
14
K2
15 J1
J2 17
R9 16
R37 18

Figure 276. Telephone Modem MD-179/TC, over-all wiring diagram.

NOTE:
ALL SWITCHES ARE SWITCHES ARE
VIEWED FROM THE END OPPOSITE
THE CONTROL KNOB.
SECTIONS DESIGNATED I ARE NEAREST
THE KNOB END.

TM5091-21


BASE LINE
1
P1
2
E1 (BOTTOM)
S1
3
4
5
SECT 1
SECT 2
SECT 3
S2
R45
R46
6
Z1
7
XV5
8
XV4
9
XV3
10
K1
11
XV2
12
XV1
13
T1
R39
14
K2
15 J1
J2 17
R9 16
R37 18
R18
19
E1 (TOP)
E1
L1
L2
L3
C17
BLU-BLK
GRN
ORN-WHT
WHT-VIO
VIO
VIO-BLK
RED-WHT
RED-YEL
BLU
WHT-BLU
BLK
BRN
GRN-BRN
YEL
BLU-WHT
BLU-YEL
WHT-BRN
BLU-RED
VIO-WHT
BLU-GRN
GRN-WHT

NOTE:
ALL SWITCHES ARE SWITCHES ARE VIEWED FROM THE END OPPOSITE THE CONTROL KNOB.
SECTIONS DESIGNATED I ARE NEAREST THE KNOB END.

TM5091-21

Figure 276. Telephone Modem MD-179/TC, over-all wiring diagram.

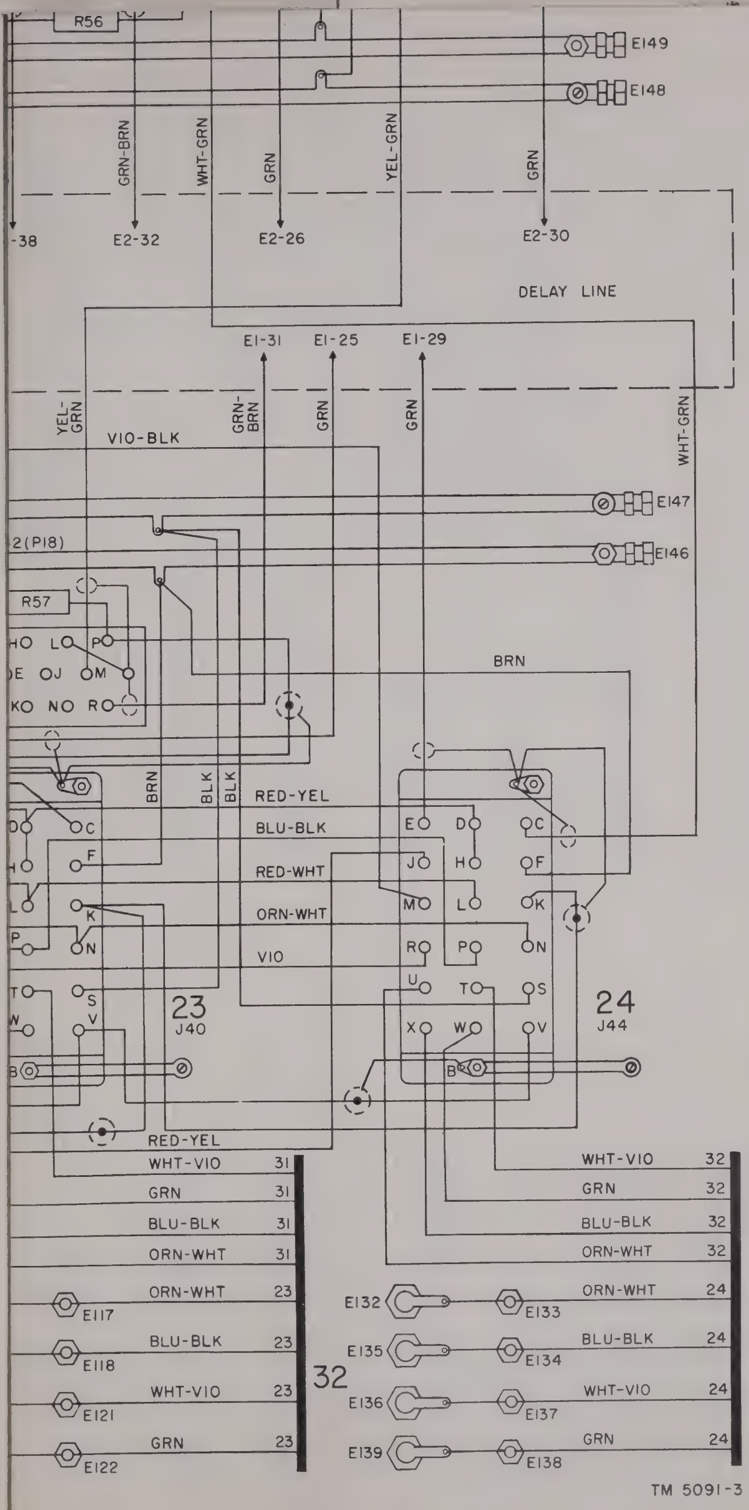

R56
E149
E148
GRN-BRN
WHT-GRN
GRN
YEL-GRN
GRN
-38
E2-32
E2-26
E2-30
DELAY LINE
E1-31
E1-25
E1-29
YEL-GRN
VIO-BLK
GRN-BRN
GRN
GRN
WHT-GRN
E147
2(P18)
E146
R57
HO LO PO
OE OJ OM O
KO NO RO
BRN
BRN
BLK
BLK
RED-YEL
BLU-BLK
RED-WHT
ORN-WHT
VIO
D C F H L K P N T S W V B
23
J40
E D C J H F M L K R P N U T S X W V B
24
J44
RED-YEL
WHT-VIO 31
GRN 31
BLU-BLK 31
ORN-WHT 31
ORN-WHT 23
BLU-BLK 23
WHT-VIO 23
GRN 23
E117
E118
E121
E122
32
WHT-VIO 32
GRN 32
BLU-BLK 32
ORN-WHT 32
ORN-WHT 24
BLU-BLK 24
WHT-VIO 24
GRN 24
E132
E133
E135
E134
E136
E137
E139
E138
TM 5091-3

Figure 277. Electrical Equipment Mounting Rack MT-1433/TCA-1, over-all wiring diagram.

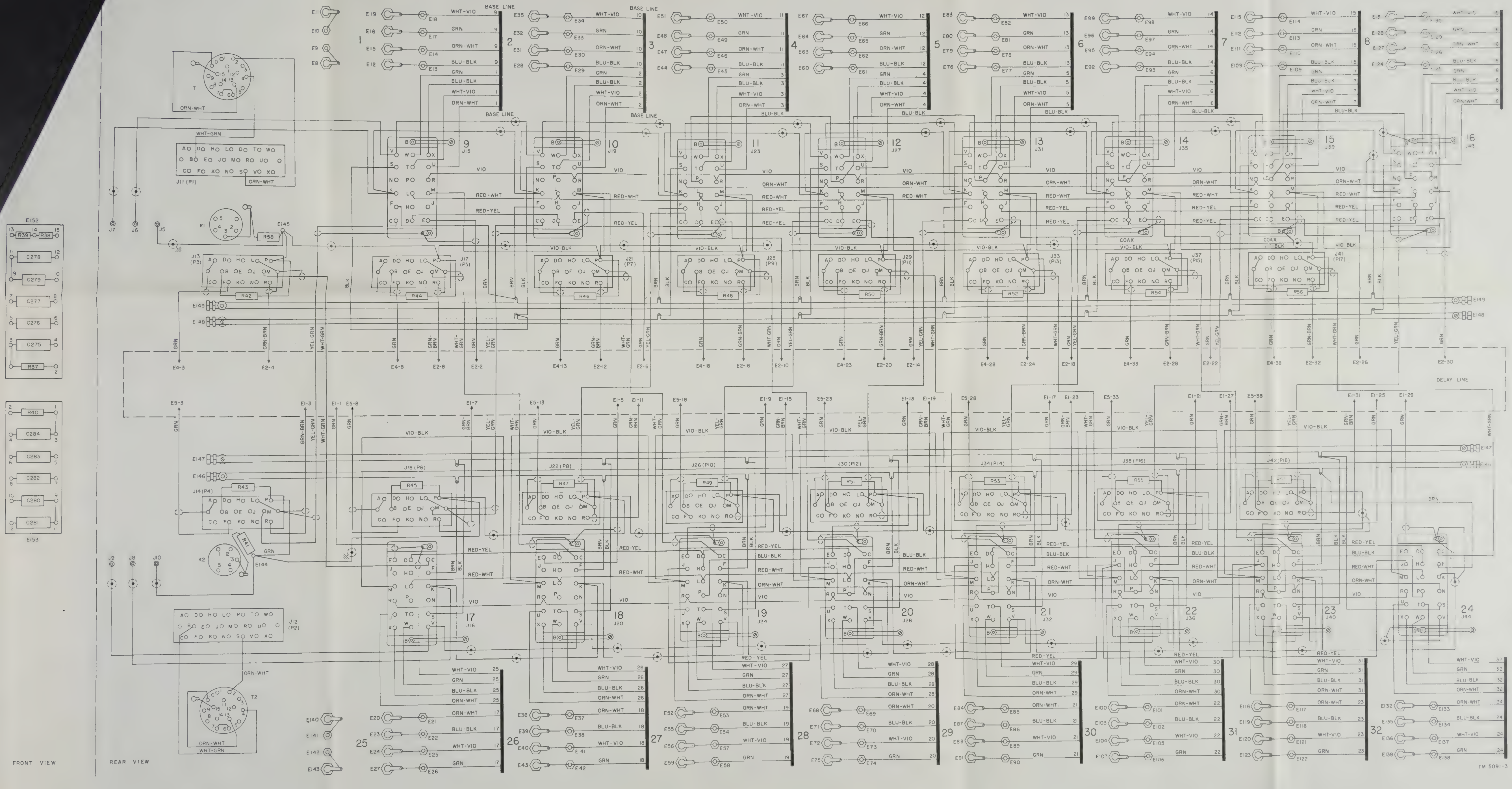
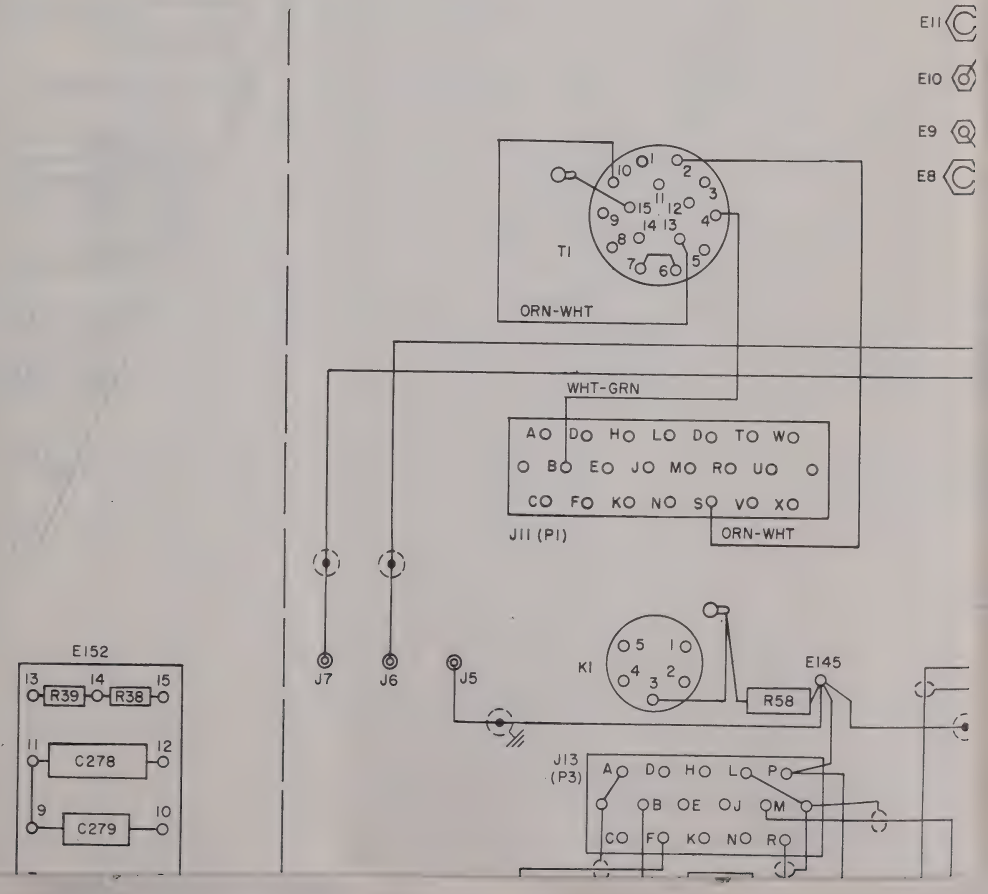
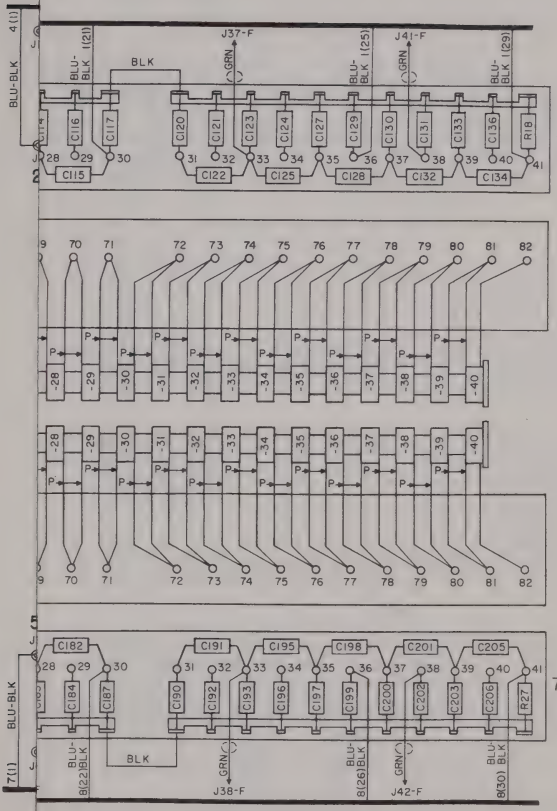

BASE LINE
DELAY LINE
COAX
FRONT VIEW
REAR VIEW
E152
E153
R39
R38
R37
R40
C278
C279
C277
C276
C275
C284
C283
C282
C280
C281
T1
T2
K1
K2
J5
J6
J7
J8
J9
J10
J11 (P1)
J12 (P2)
J13 (P3)
J14 (P4)
J15
J16
J17 (P5)
J18 (P6)
J19
J20
J21 (P7)
J22 (P8)
J23
J24
J25 (P9)
J26 (P10)
J27
J28
J29 (P11)
J30 (P12)
J31
J32
J33 (P13)
J34 (P14)
J35
J36
J37 (P15)
J38 (P16)
J39
J40
J41 (P17)
J42 (P18)
J43
J44
E144
E145
E146
E147
E148
E149
WHT-VIO
GRN
ORN-WHT
BLU-BLK
WHT-GRN
VIO
VIO-BLK
RED-WHT
RED-YEL
BRN
BLK
GRN-BRN
YEL-GRN
TM 5091-3

Figure 277. Electrical Equipment Mounting Rack MT-1483, TCA-1, over all wiring diagram.


E11
E10
E9
E8
T1
ORN-WHT
WHT-GRN
J11 (P1)
ORN-WHT
E152
R39
R38
C278
C279
J7
J6
J5
K1
E145
R58
J13
(P3)


4(1)
BLU-BLK
BLU-BLK 1(21)
BLK
J37-F
GRN
BLU-BLK 1(25)
J41-F
GRN
BLU-BLK 1(29)
C116
C117
C120
C121
C123
C124
C127
C129
C130
C131
C133
C136
R18
C115
C122
C125
C128
C132
C134
4
70
71
72
73
74
75
76
77
78
79
80
81
82
P
-28
-29
-30
-31
-32
-33
-34
-35
-36
-37
-38
-39
-40
5
C182
C191
C195
C198
C201
C205
C184
C187
C190
C192
C193
C196
C197
C199
C200
C202
C203
C206
R27
7
BLU-BLK
7(1)
BLU-BLK 8(22)
BLK
GRN
J38-F
BLU-BLK 8(26)
GRN
J42-F
BLU-BLK 8(30)

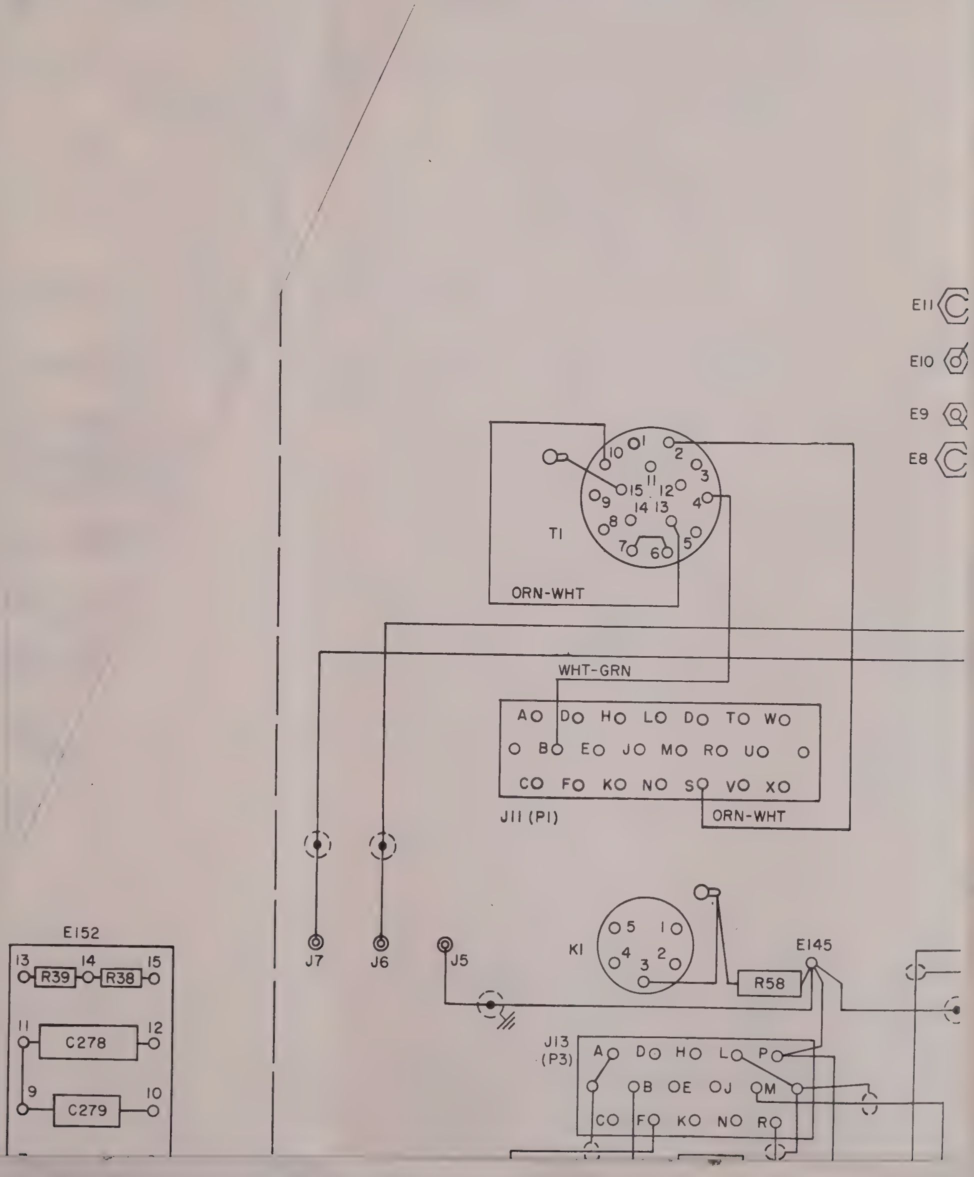
DESIGNATED ⫩ ARE TWISTED PAIRS
P

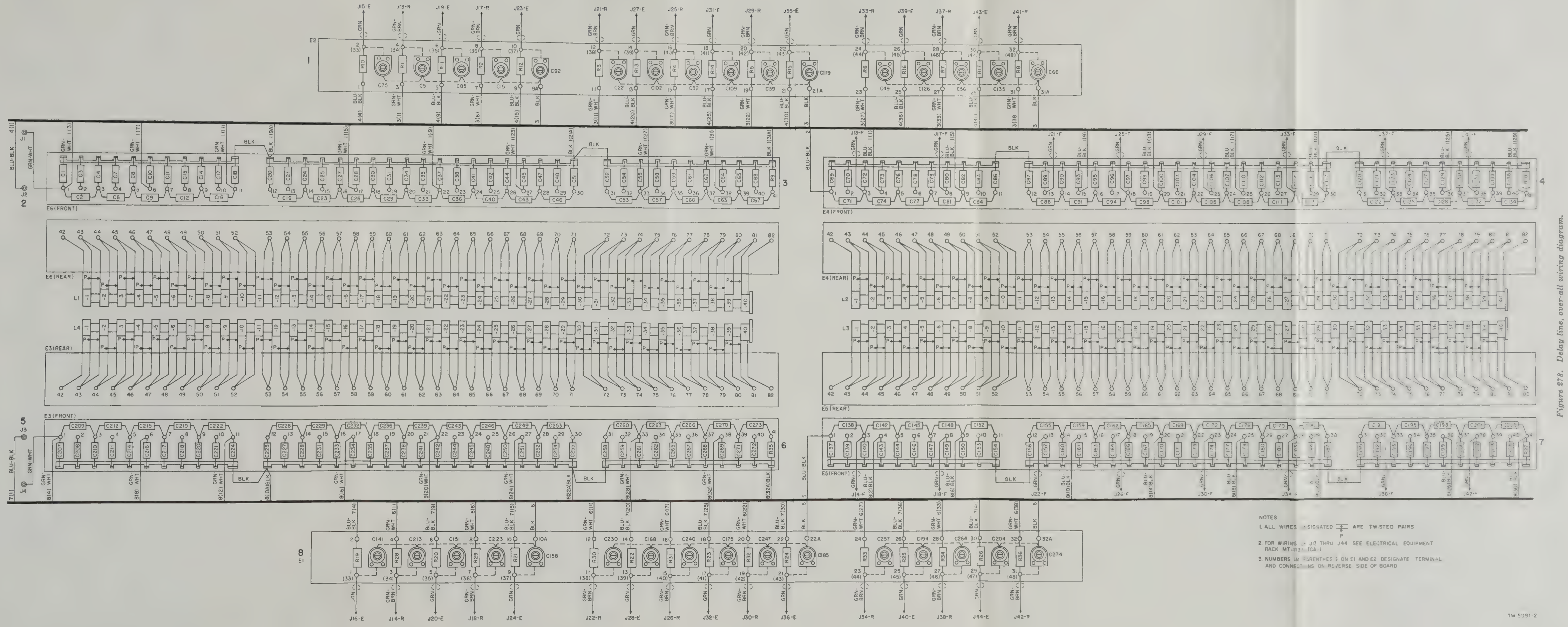
OF J13 THRU J44 SEE ELECTRICAL EQUIPMENT
33/TCA-1

N PARENTHESIS ON E1 AND E2 DESIGNATE TERMINAL
CTIONS ON REVERSE SIDE OF BOARD

TM 5091-2

Figure 278. Delay line, over-all wiring diagram.


E11
E10
E9
E8
T1
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
ORN-WHT
WHT-GRN
A
D
H
L
D
T
W
B
E
J
M
R
U
C
F
K
N
S
V
X
J11 (P1)
ORN-WHT
E152
13
14
15
R39
R38
11
12
C278
9
10
C279
J7
J6
J5
K1
1
2
3
4
5
E145
R58
J13
(P3)
A
D
H
L
P
B
E
J
M
C
F
K
N
R


1
2
3
4
5
6
7
8
E1
E2
E3(FRONT)
E3(REAR)
E4(FRONT)
E4(REAR)
E5(FRONT)
E5(REAR)
E6(FRONT)
E6(REAR)
J1
J2
J3
J4
L1
L2
L3
L4
BLU-BLK
GRN-WHT
GRN-BRN
GRN
BLK
J15-E
J13-R
J19-E
J17-R
J23-E
J21-R
J27-E
J25-R
J31-E
J29-R
J35-E
J33-R
J39-E
J37-R
J43-E
J41-R
J16-E
J14-R
J20-E
J18-R
J24-E
J22-R
J28-E
J26-R
J32-E
J30-R
J36-E
J34-R
J40-E
J38-R
J44-E
J42-R

NOTES

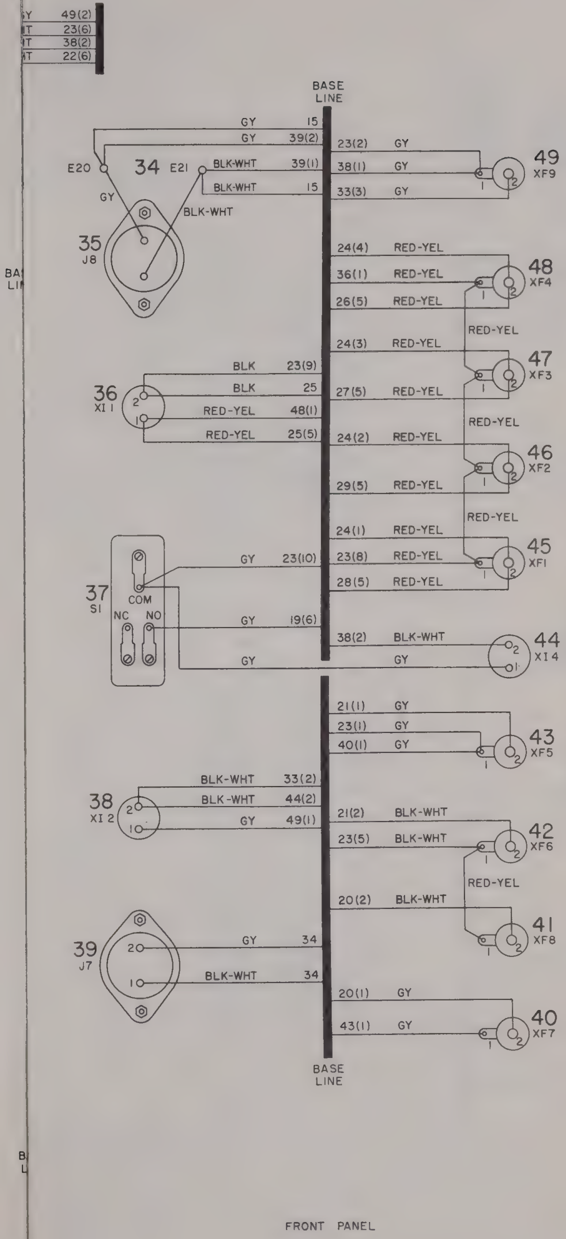
1. ALL WIRES DESIGNATED $\underset{P}{\top}$ ARE TWISTED PAIRS

2. FOR WIRING [illegible] J13 THRU J44 SEE ELECTRICAL EQUIPMENT RACK MT-113[illegible] TCA-1

3. NUMBERS IN PARENTHESES ON E1 AND E2 DESIGNATE TERMINAL AND CONNECTIONS ON REVERSE SIDE OF BOARD

TM 5091-2

Figure 278. Delay line, over-all wiring diagram.


Y 49(2)
T 23(6)
T 38(2)
T 22(6)
BA LI
B L
BASE LINE
GY 15
GY 39(2)
E20
34
E21
BLK-WHT 39(1)
BLK-WHT 15
GY
BLK-WHT
35
J8
23(2) GY
38(1) GY
33(3) GY
49
XF9
24(4) RED-YEL
36(1) RED-YEL
26(5) RED-YEL
48
XF4
RED-YEL
24(3) RED-YEL
47
XF3
BLK 23(9)
BLK 25
RED-YEL 48(1)
RED-YEL 25(5)
36
XI 1
27(5) RED-YEL
RED-YEL
24(2) RED-YEL
46
XF2
29(5) RED-YEL
RED-YEL
24(1) RED-YEL
23(8) RED-YEL
28(5) RED-YEL
45
XF1
GY 23(10)
37
S1
COM
NC
NO
GY 19(6)
38(2) BLK-WHT
GY
GY
44
XI 4
21(1) GY
23(1) GY
40(1) GY
43
XF5
BLK-WHT 33(2)
BLK-WHT 44(2)
GY 49(1)
38
XI 2
21(2) BLK-WHT
23(5) BLK-WHT
42
XF6
RED-YEL
20(2) BLK-WHT
41
XF8
39
J7
GY 34
BLK-WHT 34
20(1) GY
43(1) GY
40
XF7
BASE LINE
FRONT PANEL

TM5091-22

Figure 279. Multiplexer Subassembly MX–1442/TC, over-all wiring diagram.

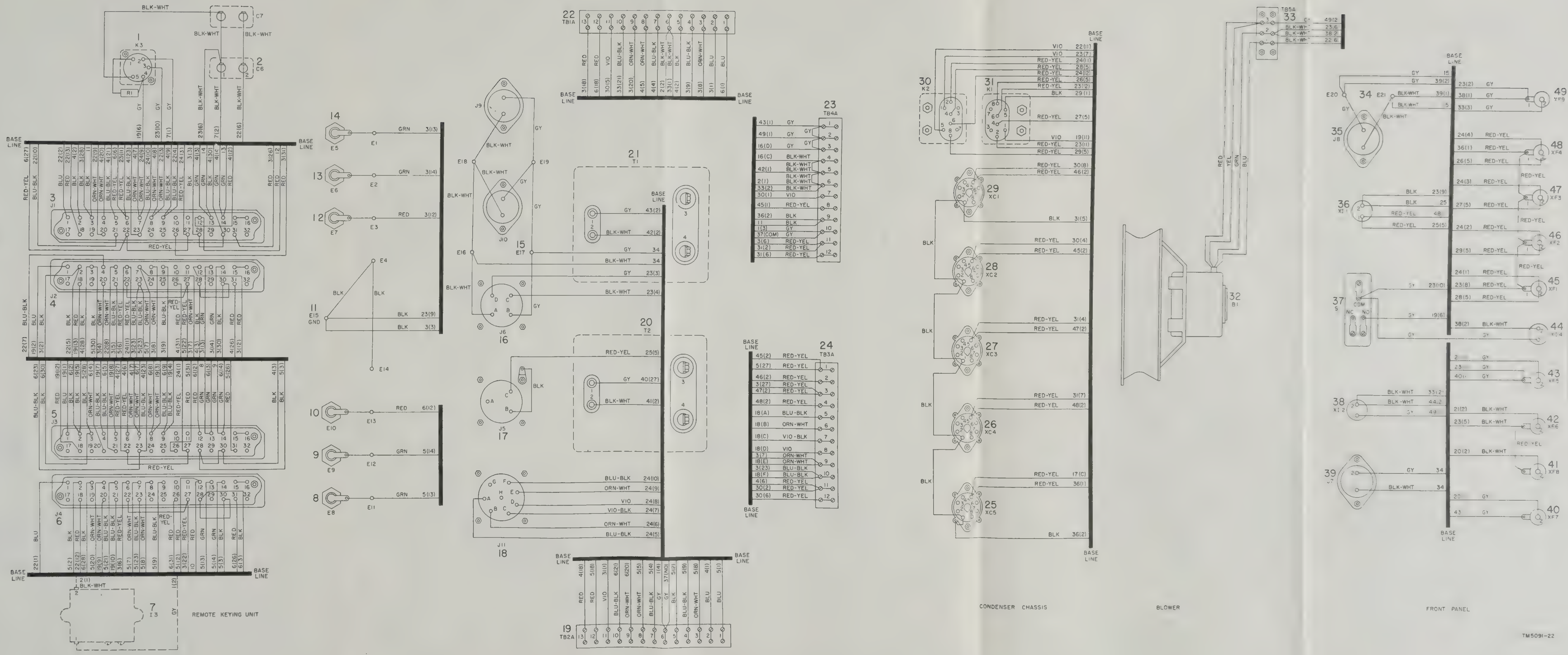

BLK-WHT
1
K3
R1
C7
2
C6
BASE LINE
3
J1
4
J2
5
J3
6
J4
7
I3
REMOTE KEYING UNIT
14
E5
E1
13
E6
E2
12
E7
E3
11
E15
GND
E4
E14
10
E10
E13
9
E9
E12
8
E8
E11
J9
E18
E19
J10
15
E16
E17
J6
16
J5
17
J11
18
22
TB1A
21
T1
20
T2
19
TB2A
23
TB4A
24
TB3A
30
K2
31
K1
29
XC1
28
XC2
27
XC3
26
XC4
25
XC5
CONDENSER CHASSIS
33
TB5A
32
B1
BLOWER
34
E20
E21
35
J8
36
XI1
37
S
COM
NC
NO
38
XI2
39
49
XF9
48
XF4
47
XF3
46
XF2
45
XF1
44
XF24
43
XF5
42
XF6
41
XF8
40
XF7
FRONT PANEL
TM5091-22

Figure 279. Multiplexer Subassembly MX-1442/TC, over-all wiring diagram.

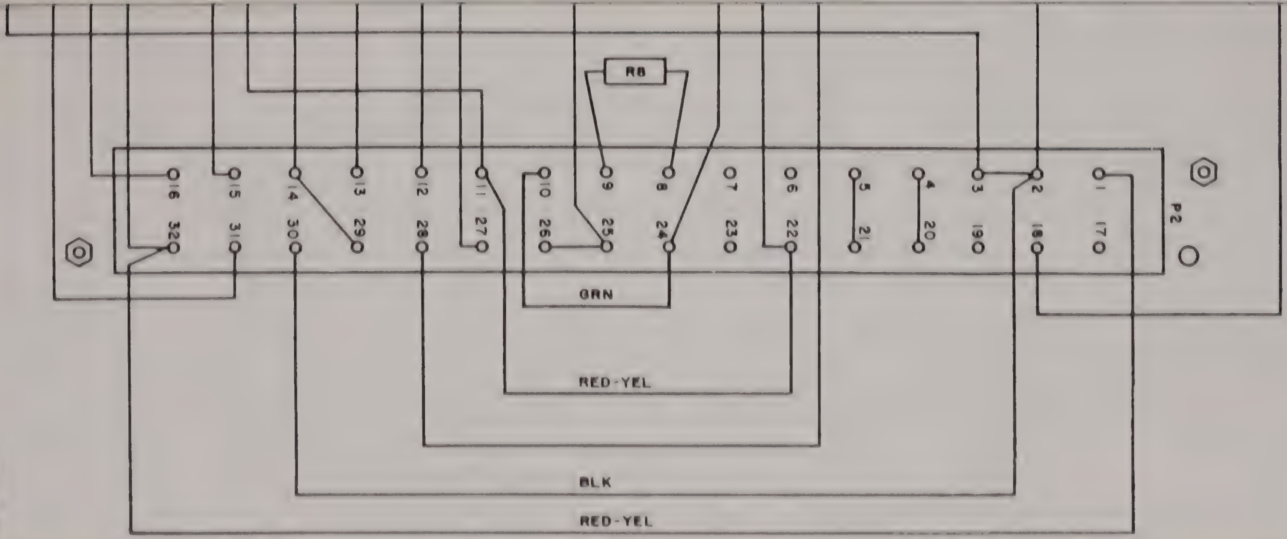

P2
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
R8
GRN
RED-YEL
BLK
RED-YEL
TM5091-23

Figure 280. Remote Switching Control C-1509/TC, over-all wiring diagram.

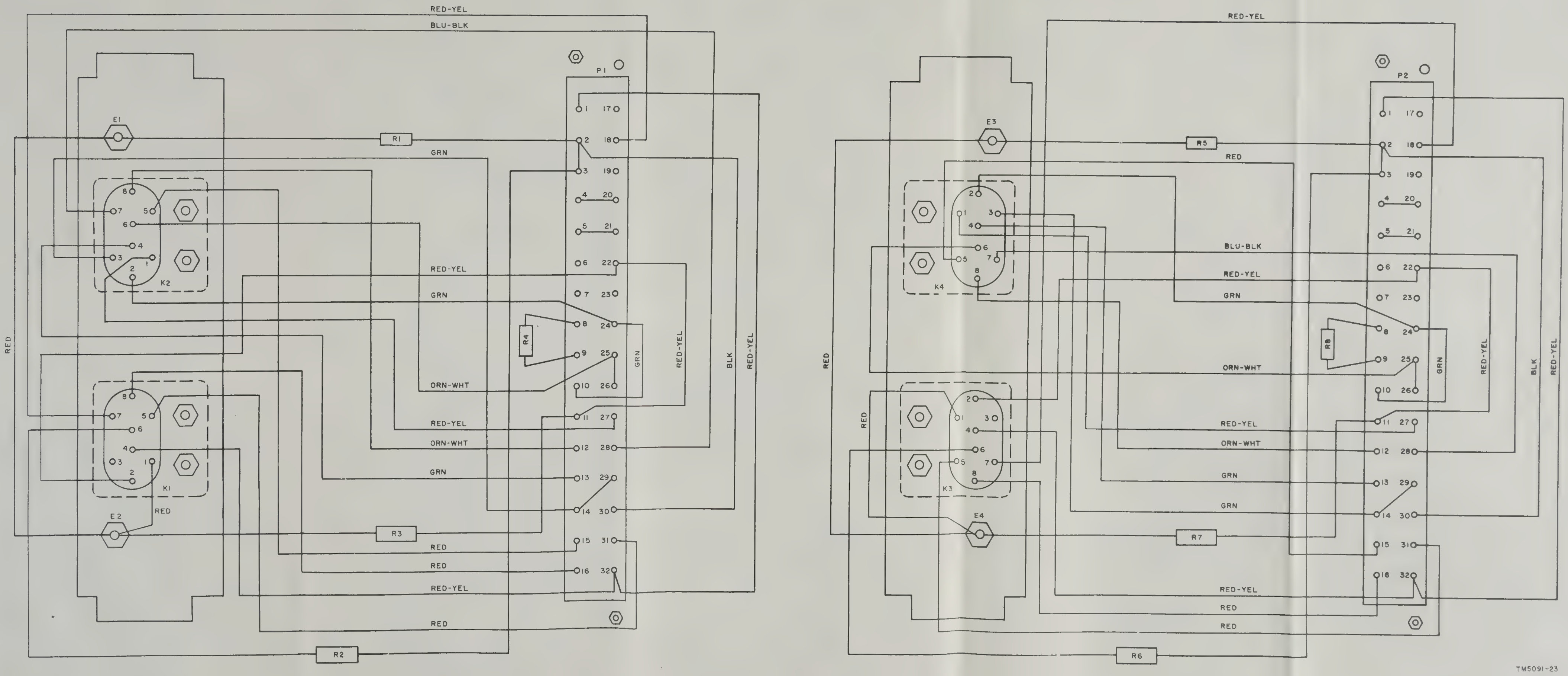

RED-YEL
BLU-BLK
P1
E1
R1
GRN
K2
RED-YEL
GRN
R4
ORN-WHT
RED-YEL
ORN-WHT
GRN
K1
E2
RED
R3
RED
RED
RED-YEL
RED
R2
GRN
RED-YEL
BLK
RED-YEL
RED-YEL
P2
E3
R5
RED
K4
BLU-BLK
RED-YEL
GRN
R8
ORN-WHT
RED-YEL
ORN-WHT
GRN
GRN
K3
E4
R7
RED-YEL
RED
RED
R6
GRN
RED-YEL
BLK
RED-YEL
TM5091-23

Figure 280. Remote Switching Control C-1509/TC, over-all wiring diagram.

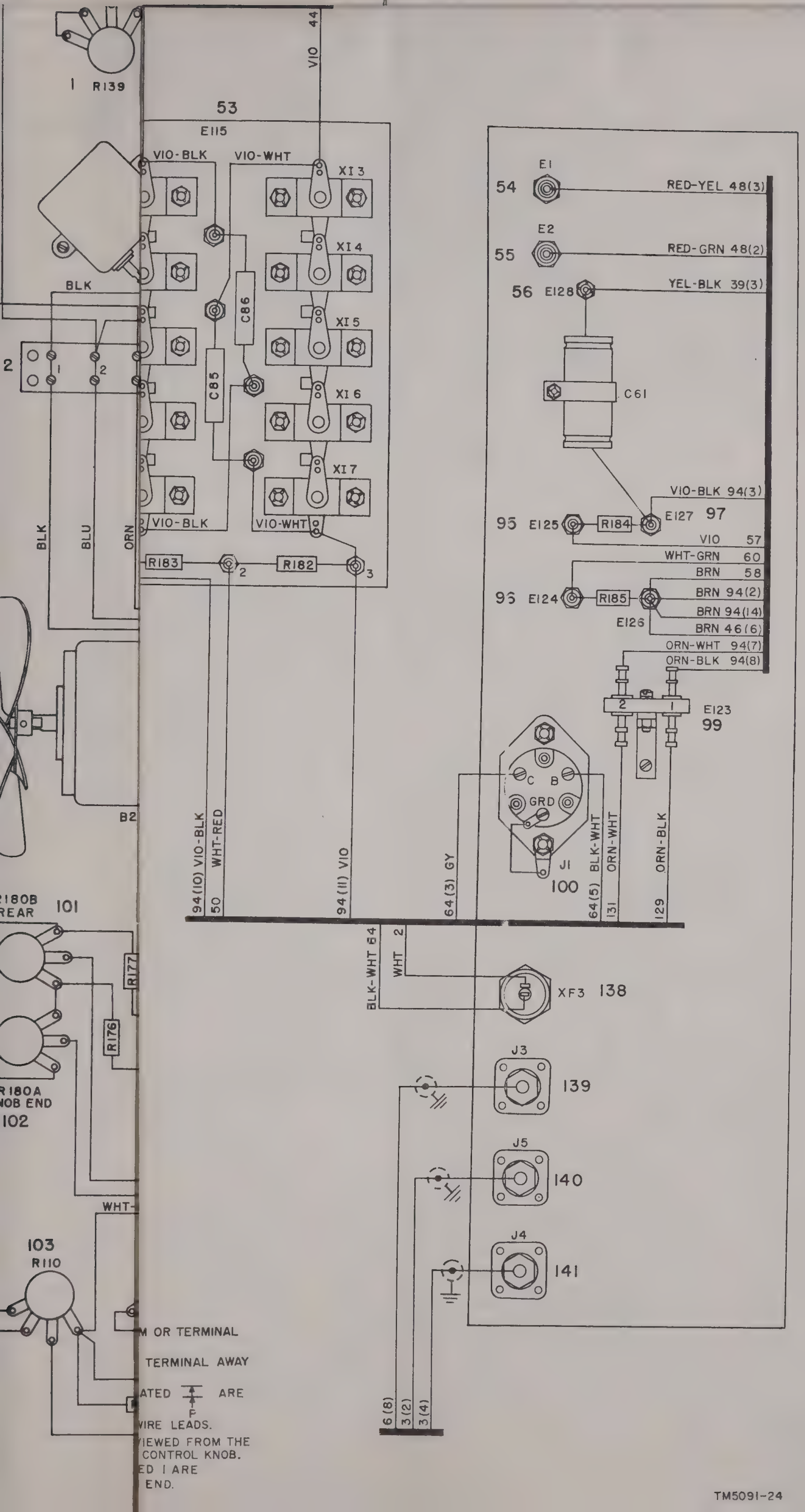
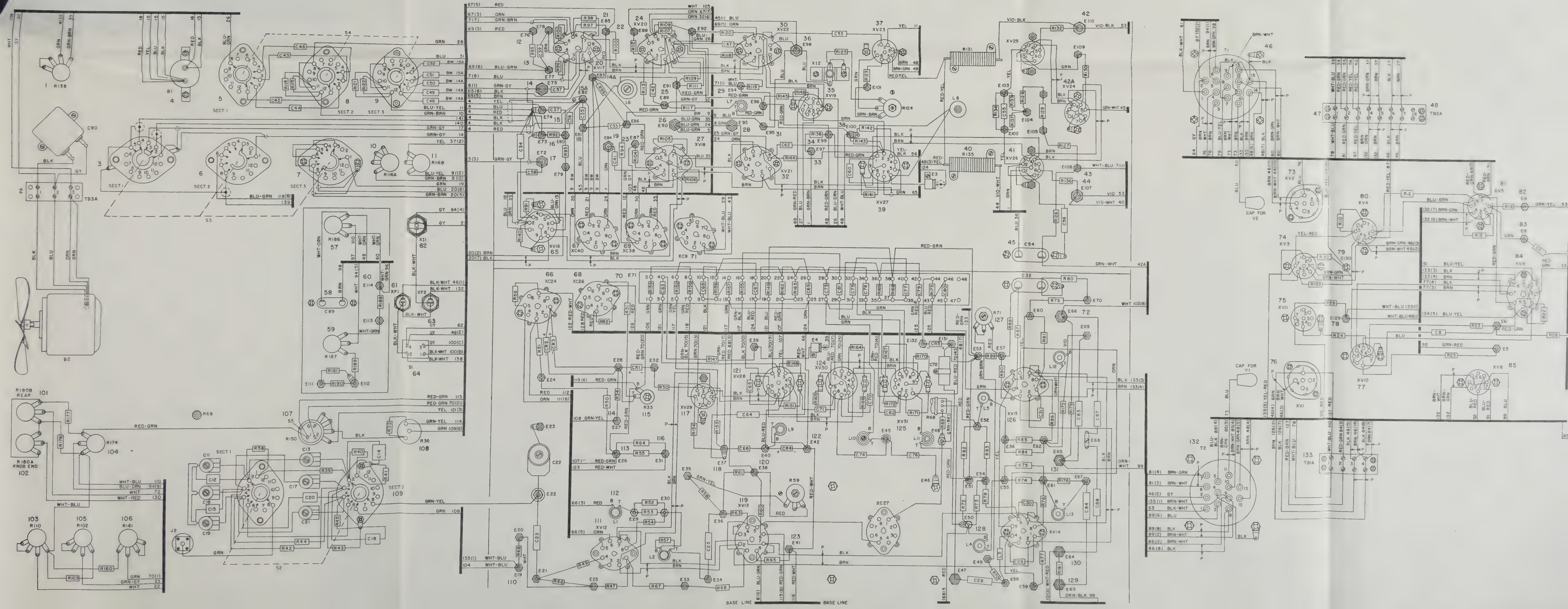
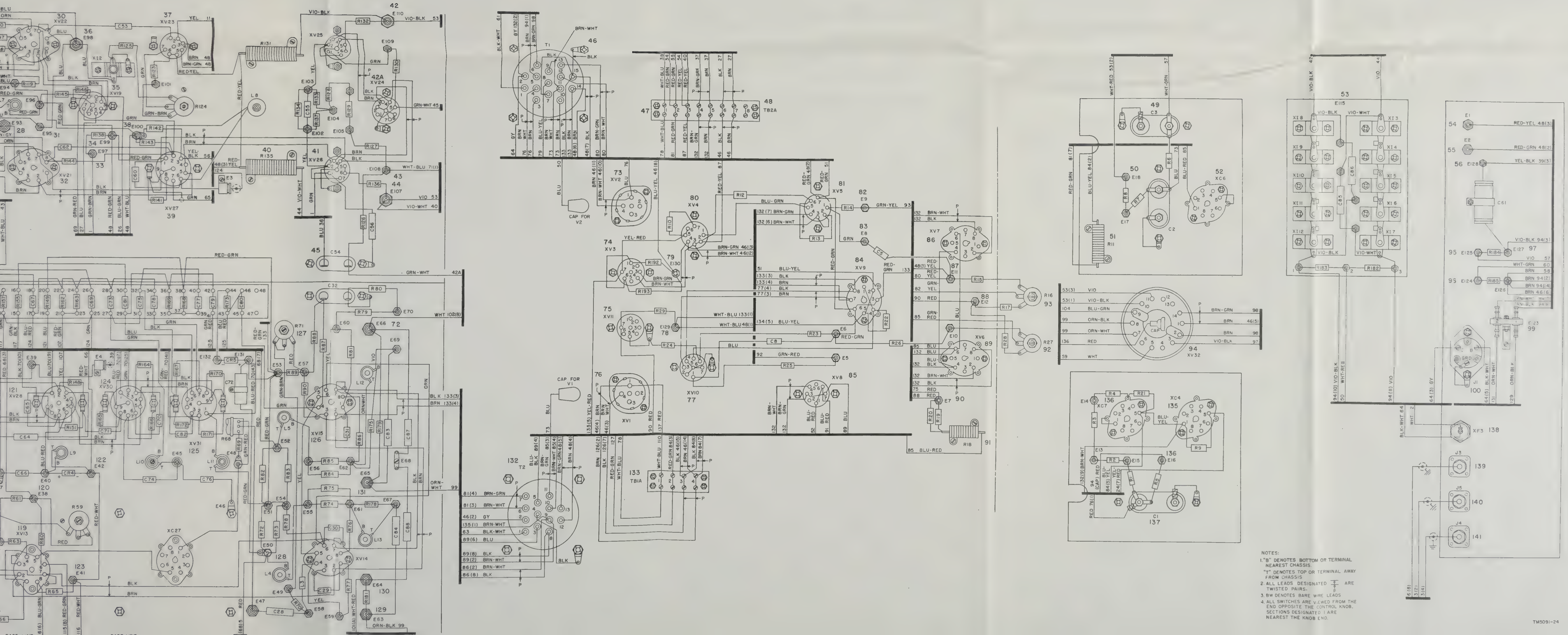

R139
1
VIO 44
53
E115
VIO-BLK
VIO-WHT
XI3
XI4
XI5
XI6
XI7
C86
C85
VIO-BLK
VIO-WHT
R183
2
R182
3
BLK
2
1
2
BLK
BLU
ORN
B2
94(10) VIO-BLK
50 WHT-RED
94(11) VIO
64(3) GY
64(5) BLK-WHT
131 ORN-WHT
129 ORN-BLK
BLK-WHT 64
WHT 2
XF3 138
E1
54
RED-YEL 48(3)
E2
55
RED-GRN 48(2)
56 E128
YEL-BLK 39(3)
C61
VIO-BLK 94(3)
95 E125
R184
E127 97
VIO 57
WHT-GRN 60
BRN 58
96 E124
R185
BRN 94(2)
BRN 94(14)
E126
BRN 46(6)
ORN-WHT 94(7)
ORN-BLK 94(8)
2
1
E123
99
C
B
GRD
J1
100
J3
139
J5
140
J4
141
6(8)
3(2)
3(4)
R180B
REAR
101
R177
R176
R180A
NOB END
102
WHT-
103
R110
M OR TERMINAL
TERMINAL AWAY
ATED
ARE
F
VIRE LEADS.
VIEWED FROM THE
CONTROL KNOB.
ED 1 ARE
END.
TM5091-24

Figure 281. Oscilloscope OS-25/G, over-all wiring diagram.


R139
B1
SECT 1
SECT 2
SECT 3
S3
S4
C90
TB3A
B2
R180B REAR
R180A KNOB END
101
102
R174
104
103 R110
105 R102
106 R161
J2
S2
107 S5
R150
108
109
XV17
XV20
XV22
XV23
XV25
XV24
XV18
XV19
XV21
XV27
XV26
XV16
XC40
XC38
XC9
XC24
XC26
XV28
XV29
XV30
XV31
XV12
XV13
XC27
XV15
XV14
T1
TB2A
XV2
XV3
XV11
XV1
XV10
XV4
XV5
XV9
XV8
T2
TB1A
CAP FOR V2
CAP FOR V1
L1
L2
L5
L6
L8
L9
L10
L11
L12
L13
R131
R135
C22
C23
C25
C28
C54
BASE LINE
RED-GRN
GRN-WHT
WHT-BLU
BLU-GRN
BLK-WHT
VIO-BLK
VIO-WHT

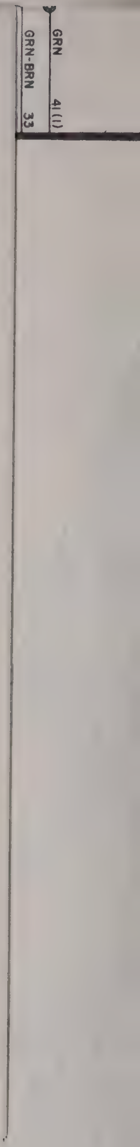

XV22
XV23
XV25
XV24
XV26
XV27
XV21
XV19
XV28
XV30
XV31
XV13
XV14
XV15
XC27
T1
T2
XV2
XV3
XV4
XV5
XV6
XV7
XV8
XV9
XV10
XV11
XV1
TB2A
TB1A
XV32
XC6
XC7
XC4
C1
C2
C3
C61
XF3
J1
J3
J4
J5
CAP FOR V1
CAP FOR V2
VIO-BLK
GRN-WHT
RED-GRN
BLU-RED
TM5091-24

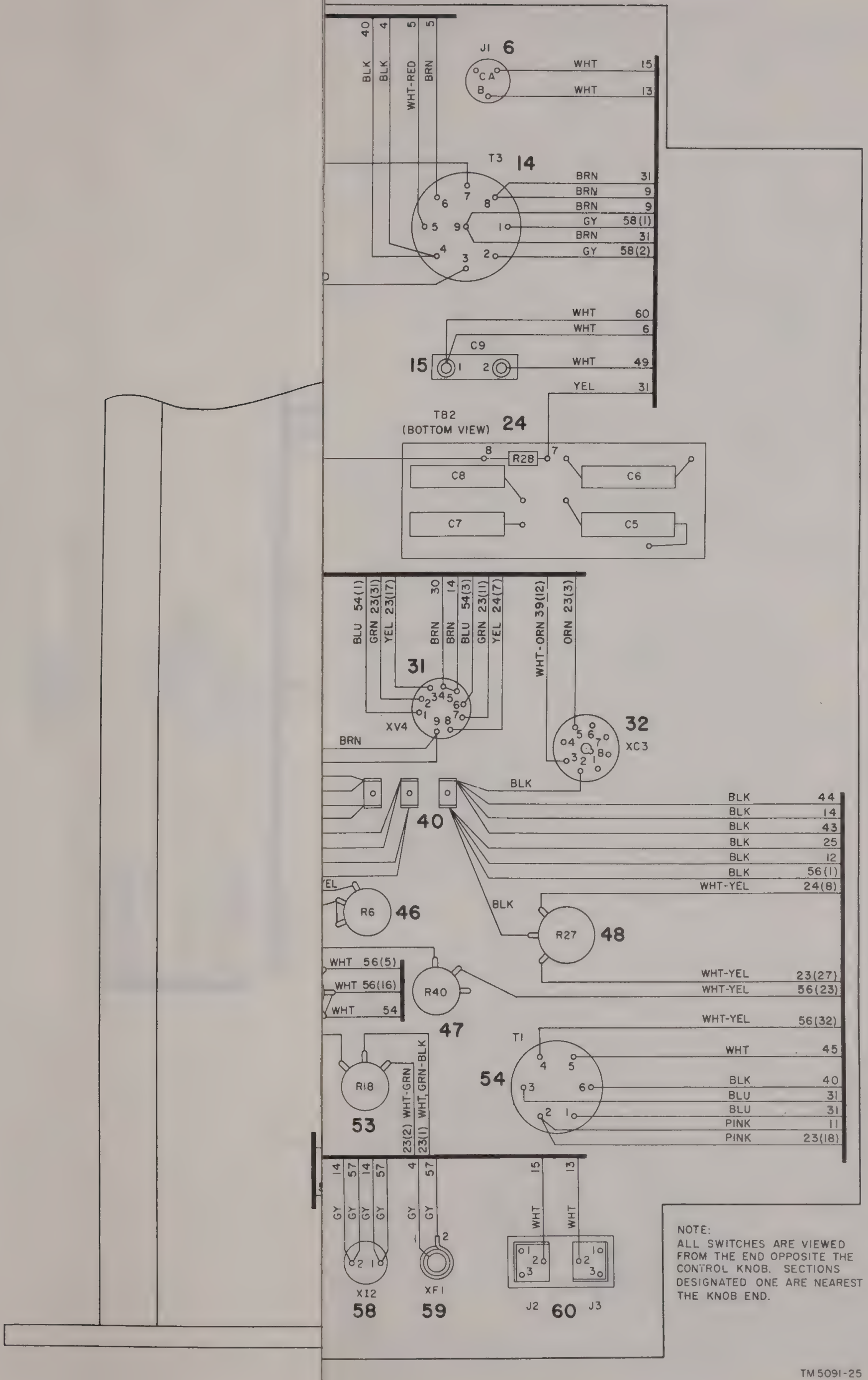
NOTES:

1. "B" DENOTES BOTTOM OR TERMINAL NEAREST CHASSIS.

   "T" DENOTES TOP OR TERMINAL AWAY FROM CHASSIS
2. ALL LEADS DESIGNATED ╪ ARE TWISTED PAIRS.
3. BW DENOTES BARE WIRE LEADS
4. ALL SWITCHES ARE VIEWED FROM THE END OPPOSITE THE CONTROL KNOB. SECTIONS DESIGNATED I ARE NEAREST THE KNOB END.

Figure 281. Oscilloscope OS-25/G, over-all wiring diagram.

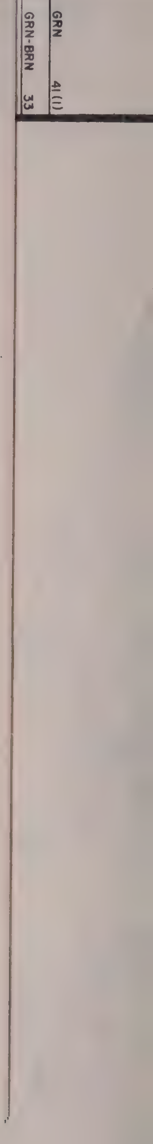

GRN
41(1)
GRN-BRN
33

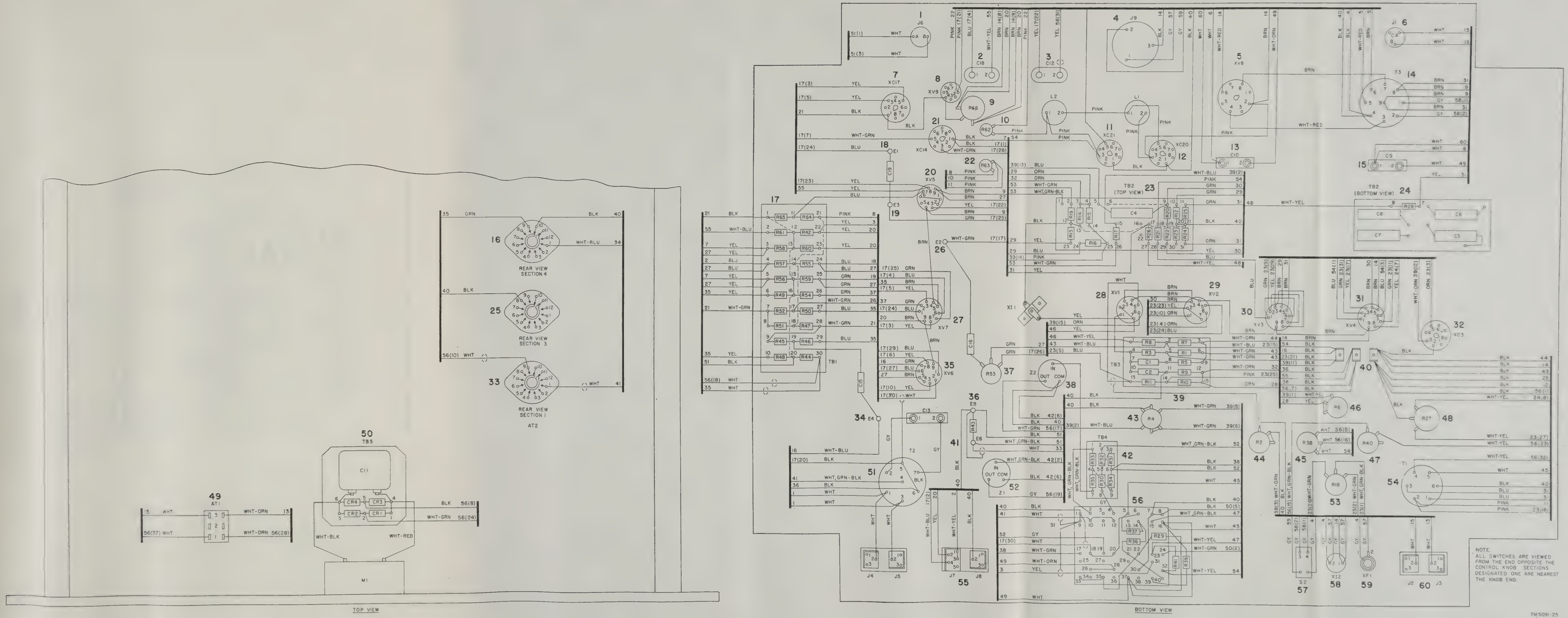

BLK 40
BLK 4
WHT-RED 5
BRN 5
J1 6
C A B
WHT 15
WHT 13
T3 14
BRN 31
BRN 9
BRN 9
GY 58(1)
BRN 31
GY 58(2)
WHT 60
WHT 6
C9
15
WHT 49
YEL 31
TB2 (BOTTOM VIEW) 24
R28
C8
C6
C7
C5
BLU 54(1)
GRN 23(3)
YEL 23(17)
BRN 30
BRN 14
BLU 54(3)
GRN 23(11)
YEL 24(7)
WHT-ORN 39(12)
ORN 23(3)
31
XV4
BRN
32
XC3
BLK
40
BLK 44
BLK 14
BLK 43
BLK 25
BLK 12
BLK 56(1)
WHT-YEL 24(8)
YEL
R6 46
BLK
R27 48
WHT 56(5)
WHT 56(16)
WHT 54
R40
47
WHT-YEL 23(27)
WHT-YEL 56(23)
WHT-YEL 56(32)
T1
WHT 45
BLK 40
BLU 31
BLU 31
PINK 11
PINK 23(18)
54
R18
53
23(2) WHT-GRN
23(1) WHT, GRN-BLK
GY 14
GY 57
GY 14
GY 57
GY 4
GY 57
WHT 15
WHT 13
XI2
58
XF1
59
J2 60 J3

NOTE:
ALL SWITCHES ARE VIEWED FROM THE END OPPOSITE THE CONTROL KNOB. SECTIONS DESIGNATED ONE ARE NEAREST THE KNOB END.

TM5091-25

Figure 282. Audio Test Set TS-762/TC, over-all wiring diagram.


GRN
41 (1)
GRN-BRN
33


TOP VIEW
BOTTOM VIEW
REAR VIEW SECTION 4
REAR VIEW SECTION 3
REAR VIEW SECTION 1
AT2
AT1
TB5
C11
CR1
CR2
CR3
CR4
M1
TB1
TB2 (TOP VIEW)
TB2 (BOTTOM VIEW)
TB3
TB4
J1
J2
J3
J4
J5
J6
J7
J8
J9
XV1
XV2
XV3
XV4
XV5
XV6
XV7
XV8
XV9
XC3
XC14
XC17
XC20
XC21
XI1
XI2
XF1
T1
T2
T3
L1
L2
S1
S2
Z1
Z2
E1
E2
E3
E4
E5
E6
R2
R4
R6
R18
R27
R38
R40
R53
R62
R63
R66
C5
C6
C7
C8
C9
C10
C12
C13
C15
C16
C18
C19
IN
OUT COM
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
BLK
WHT
YEL
BLU
GRN
BRN
PINK
ORN
GY
WHT-BLU
WHT-GRN
WHT-YEL
WHT-ORN
WHT-RED
WHT-BLK
WHT-GRN-BLK

NOTE.
ALL SWITCHES ARE VIEWED FROM THE END OPPOSITE THE CONTROL KNOB SECTIONS DESIGNATED ONE ARE NEAREST THE KNOB END.

TM5091-25

Figure 282. Audio Test Set TS-762/TC, over-all wiring diagram.

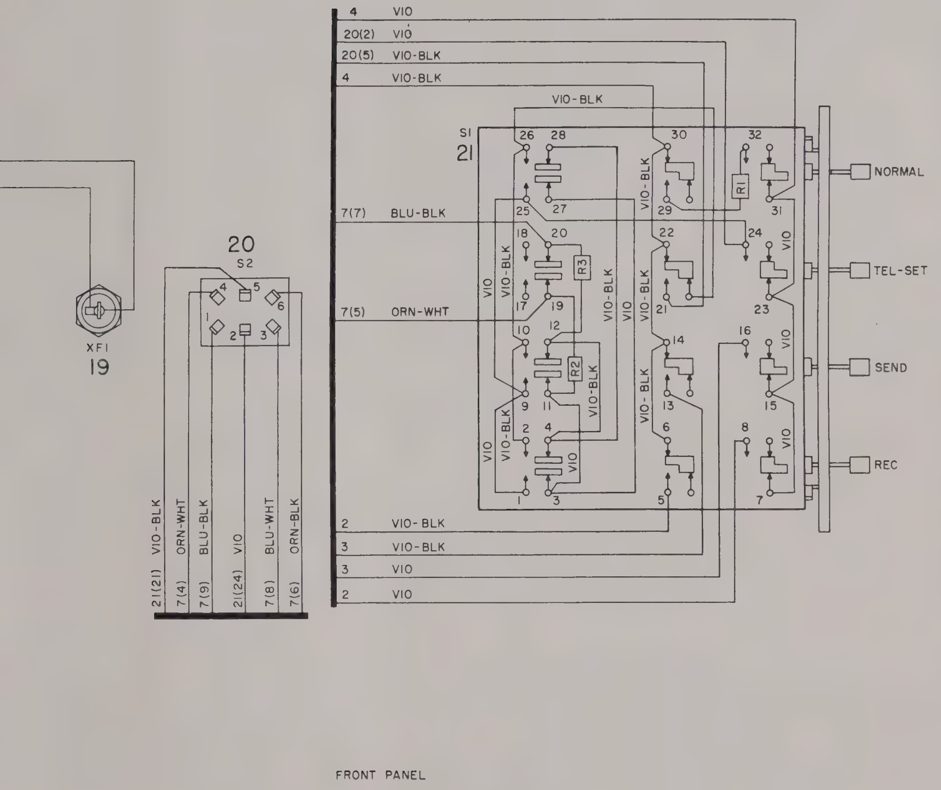

4 VIO
20(2) VIO
20(5) VIO-BLK
4 VIO-BLK
VIO-BLK
S1
21
7(7) BLU-BLK
7(5) ORN-WHT
26
28
27
25
30
29
32
31
R1
18
20
R3
17
19
22
21
24
23
10
12
R2
9
11
14
13
16
15
2
4
1
3
6
5
8
7
VIO
VIO-BLK
NORMAL
TEL-SET
SEND
REC
2 VIO-BLK
3 VIO-BLK
3 VIO
2 VIO
20
S2
1
2
3
4
5
6
XF1
19
21(21) VIO-BLK
7(4) ORN-WHT
7(9) BLU-BLK
21(24) VIO
7(8) BLU-WHT
7(6) ORN-BLK
FRONT PANEL
TM5091-26

Figure 283. Control Monitor C-1151/TC, over-all wiring diagram.

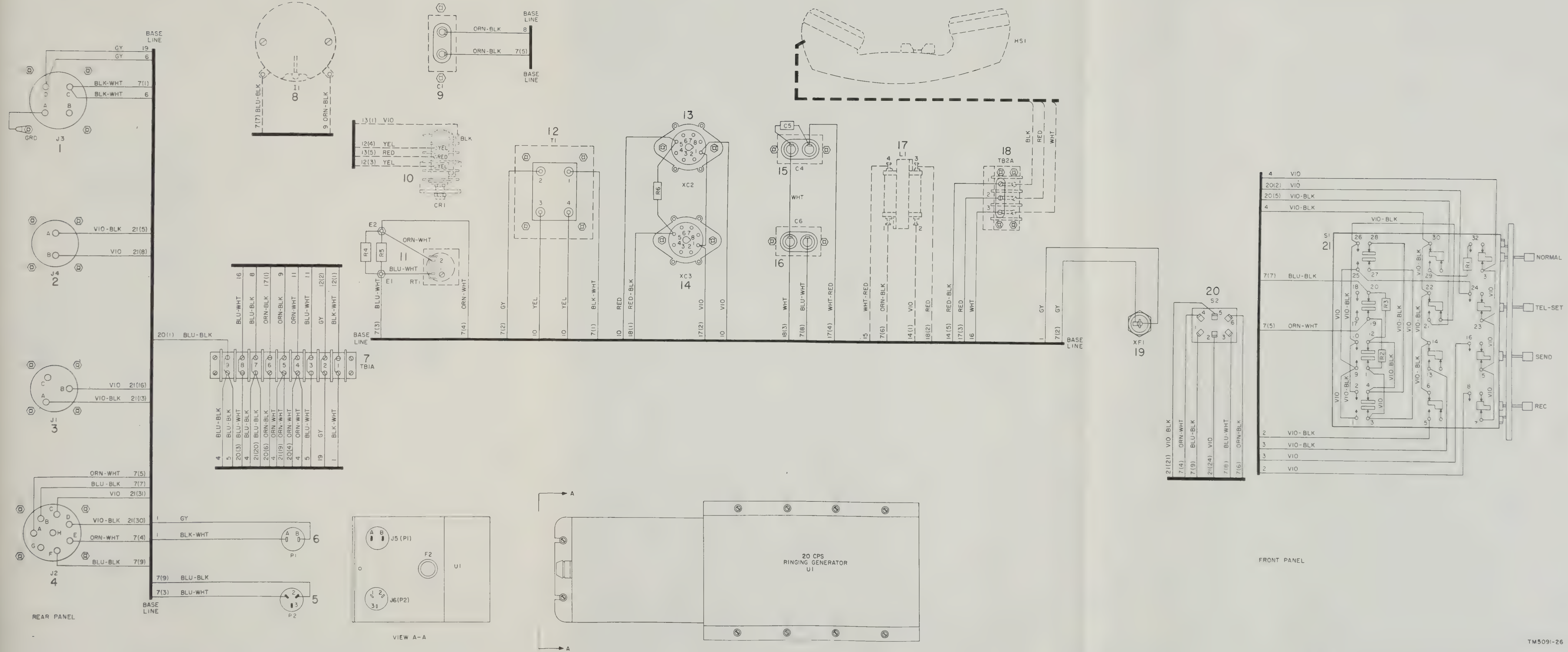
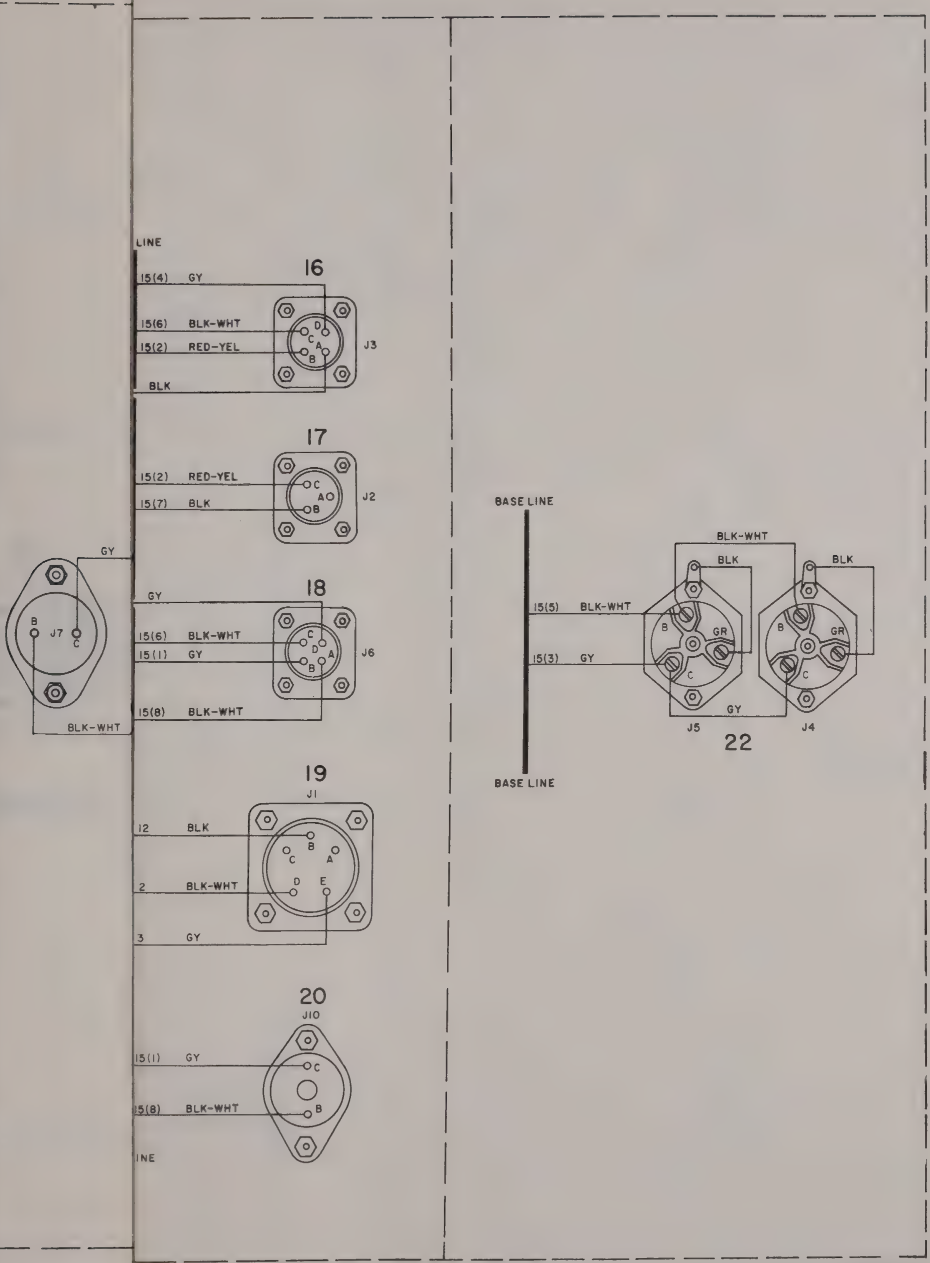

BASE LINE
GY 19
GY 6
BLK-WHT 7(1)
BLK-WHT 6
GRD
J3
1
VIO-BLK 21(5)
VIO 21(8)
J4
2
VIO 21(16)
VIO-BLK 21(13)
J1
3
ORN-WHT 7(5)
BLU-BLK 7(7)
VIO 21(31)
VIO-BLK 21(30)
ORN-WHT 7(4)
BLU-BLK 7(9)
J2
4
REAR PANEL
GY
BLK-WHT
P1
6
7(9) BLU-BLK
7(3) BLU-WHT
P2
5
I1
8
7(7) BLU-BLK
9 ORN-BLK
C1
9
ORN-BLK 8
ORN-BLK 7(5)
13(1) VIO
12(4) YEL
13(5) RED
12(3) YEL
BLK
10
CR1
20(1) BLU-BLK
7
TB1A
E2
E1
R4
R5
ORN-WHT
BLU-WHT
11
RT1
12
T1
13
XC2
R6
XC3
14
C5
15
C4
WHT
C6
16
17
L1
18
TB2A
BLK
RED
WHT
HS1
GY
XF1
19
20
S2
21
S1
VIO-BLK
BLU-BLK
ORN-WHT
R1
R2
R3
NORMAL
TEL-SET
SEND
REC
FRONT PANEL
J5 (P1)
F2
U1
J6(P2)
VIEW A-A
A
20 CPS
RINGING GENERATOR
U1
TM5091-26

Figure 283. Control Monitor C-1151/TC, over-all wiring diagram.


LINE
16
15(4) GY
15(6) BLK-WHT
15(2) RED-YEL
BLK
D
C
A
B
J3
17
15(2) RED-YEL
15(7) BLK
C
A
B
J2
GY
B
J7
C
BLK-WHT
18
GY
15(6) BLK-WHT
15(1) GY
15(8) BLK-WHT
C
D
A
B
J6
19
J1
12 BLK
2 BLK-WHT
3 GY
B
C
A
D
E
20
J10
15(1) GY
15(8) BLK-WHT
C
B
INE
BASE LINE
15(5) BLK-WHT
15(3) GY
BASE LINE
BLK-WHT
BLK
BLK
B
GR
C
B
GR
C
GY
J5
J4
22

TM5091-27

Figure 284. Power Supply PP-691/G, over-all wiring diagram.

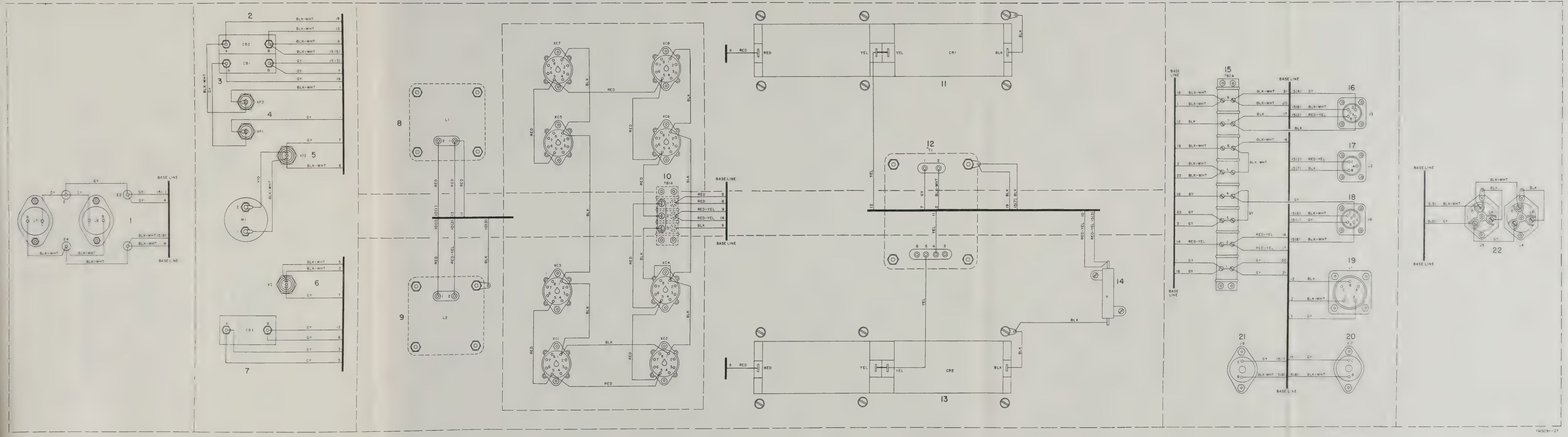

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
BASE LINE
E1
E2
E3
E4
CB1
CB2
XF1
XF2
XI
XI2
M1
L1
L2
XC1
XC2
XC3
XC4
XC5
XC6
XC7
XC8
TB1A
CR1
CR2
T1
TB2A
J1
J2
J3
J4
J5
J6
RED
YEL
BLK
GY
BLK-WHT
RED-YEL
TM5091-27

Figure 284. Power Supply PP-691/G, over-all wiring diagram.

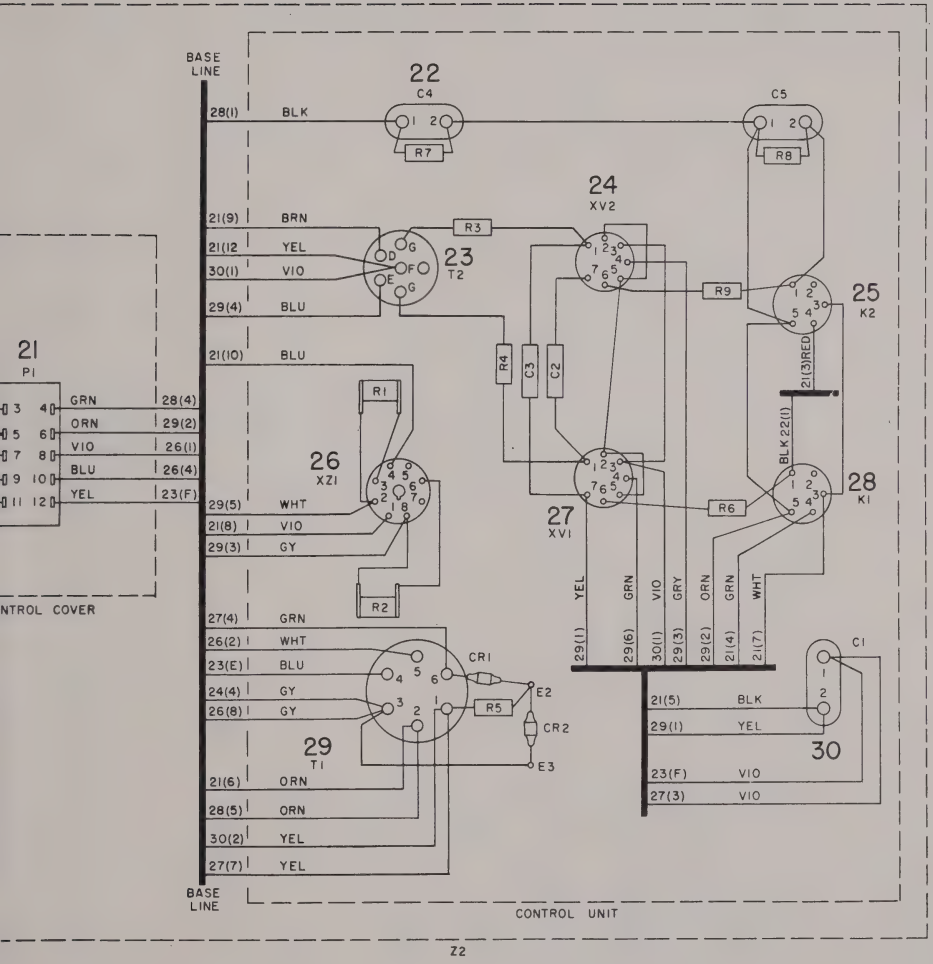

BASE LINE
22
C4
C5
R7
R8
28(1) BLK
24
XV2
R3
21(9) BRN
21(12 YEL
30(1) VIO
29(4) BLU
23
T2
D G F E G
R9
25
K2
21(10) BLU
21(3)RED
R4
C3
C2
R1
21
P1
3 4 GRN 28(4)
5 6 ORN 29(2)
7 8 VIO 26(1)
9 10 BLU 26(4)
11 12 YEL 23(F)
26
XZ1
BLK 22(1)
28
K1
R6
27
XV1
29(5) WHT
21(8) VIO
29(3) GY
R2
NTROL COVER
YEL GRN VIO GRY ORN GRN WHT
29(1) 29(6) 30(1) 29(3) 29(2) 21(4) 21(7)
27(4) GRN
26(2) WHT
23(E) BLU
24(4) GY
26(8) GY
CR1
E2
R5
CR2
E3
29
T1
C1
21(5) BLK
29(1) YEL
30
23(F) VIO
27(3) VIO
21(6) ORN
28(5) ORN
30(2) YEL
27(7) YEL
BASE LINE
CONTROL UNIT
Z2
TM5091-28

Figure 285. Voltage Regulator CN-236/G, over-all wiring diagram.

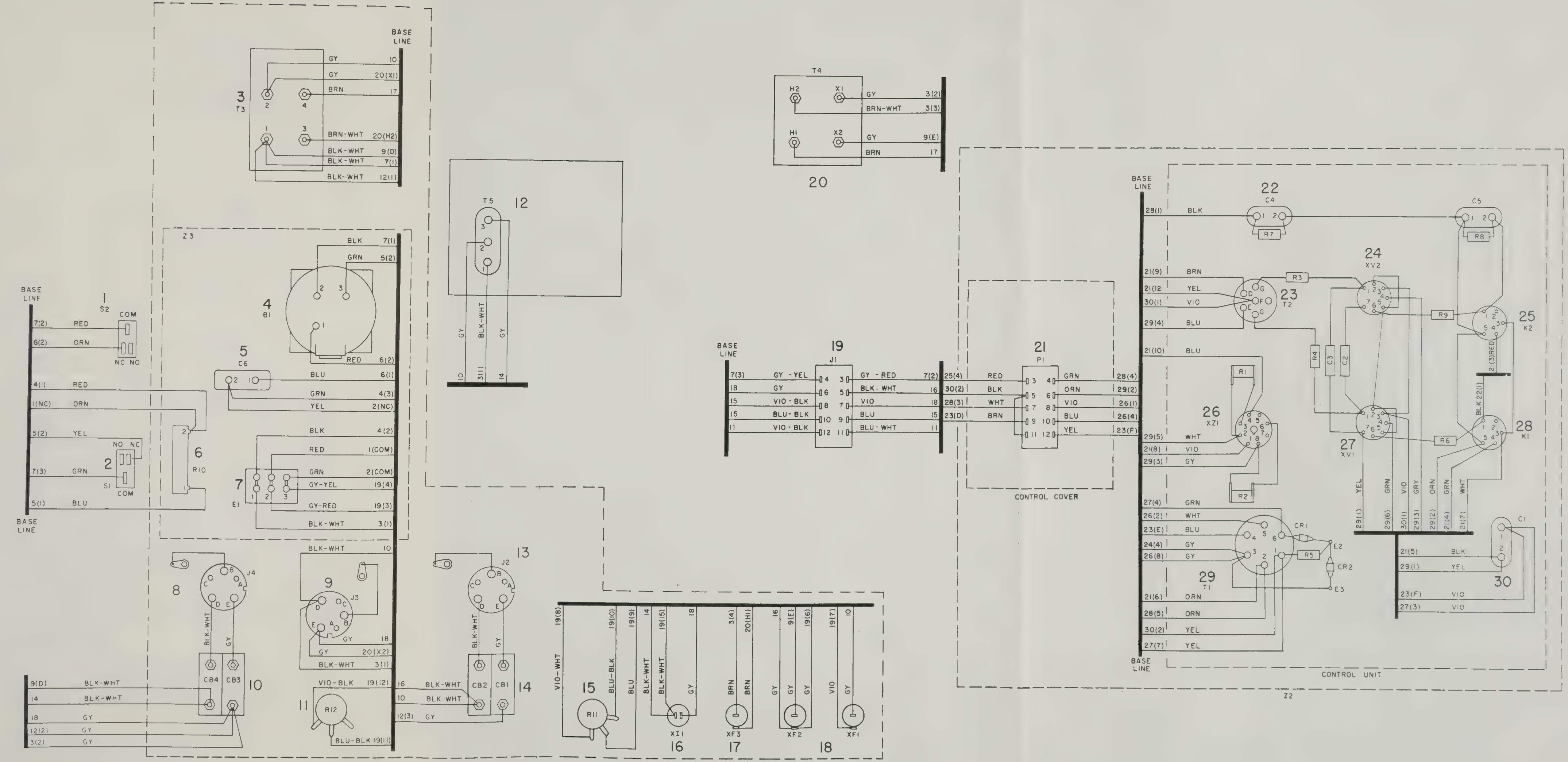
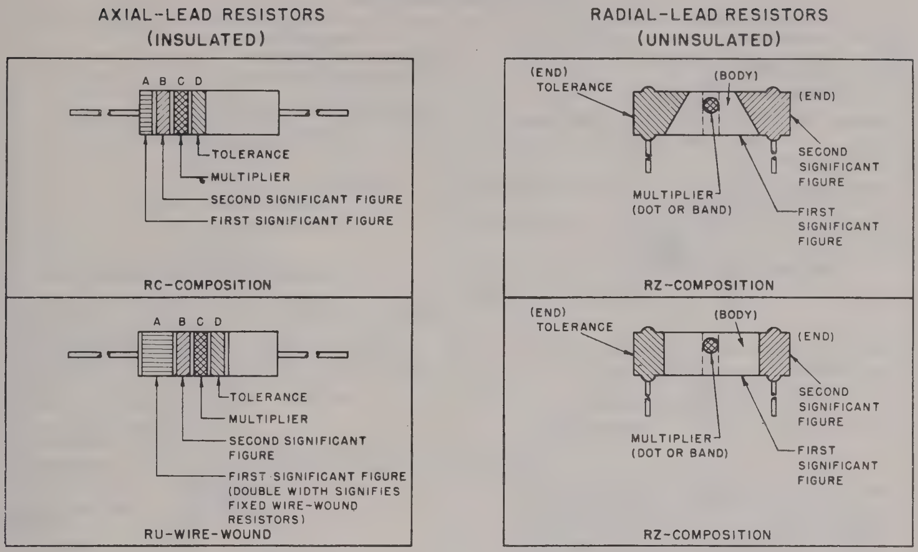

BASE LINE
1
S2
COM
NC NO
2
S1
NO NC
3
T3
4
B1
5
C6
6
R10
7
E1
8
J4
9
J3
10
CB4
CB3
11
R12
12
T5
13
J2
14
CB2
CB1
15
R11
16
XI1
17
XF3
18
XF2
XF1
19
J1
20
T4
H2
X1
H1
X2
21
P1
CONTROL COVER
22
C4
R7
C5
R8
23
T2
24
XV2
R3
25
K2
R9
R4
C3
C2
26
XZ1
R1
R2
27
XV1
R6
28
K1
29
T1
CR1
CR2
R5
E2
E3
30
C1
Z3
Z2
CONTROL UNIT
TM5091-28

Figure 285. Voltage Regulator CN-236/G, over-all wiring diagram.

RESISTOR COLOR CODE MARKING
(MIL-STD RESISTORS)


AXIAL-LEAD RESISTORS
(INSULATED)
RADIAL-LEAD RESISTORS
(UNINSULATED)
A B C D
TOLERANCE
MULTIPLIER
SECOND SIGNIFICANT FIGURE
FIRST SIGNIFICANT FIGURE
RC-COMPOSITION
A B C D
TOLERANCE
MULTIPLIER
SECOND SIGNIFICANT FIGURE
FIRST SIGNIFICANT FIGURE (DOUBLE WIDTH SIGNIFIES FIXED WIRE-WOUND RESISTORS)
RU-WIRE-WOUND
(END) TOLERANCE
(BODY)
(END)
SECOND SIGNIFICANT FIGURE
MULTIPLIER (DOT OR BAND)
FIRST SIGNIFICANT FIGURE
RZ-COMPOSITION
(END) TOLERANCE
(BODY)
(END)
SECOND SIGNIFICANT FIGURE
MULTIPLIER (DOT OR BAND)
FIRST SIGNIFICANT FIGURE
RZ-COMPOSITION

RESISTOR COLOR CODE

BAND A OR BODY*		BAND B OR END*		BAND C OR DOT OR BAND*		BAND D OR END*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1	BODY	± 20
BROWN	1	BROWN	1	BROWN	10	SILVER	± 10
RED	2	RED	2	RED	100	GOLD	± 5
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000		
GREEN	5	GREEN	5	GREEN	100,000		
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	GOLD	0.1		
WHITE	9	WHITE	9	SILVER	0.01		

*FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH.
WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR,
THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

EXAMPLES (BAND MARKING):
10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B; BLACK BAND C; NO BAND D.
4.7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

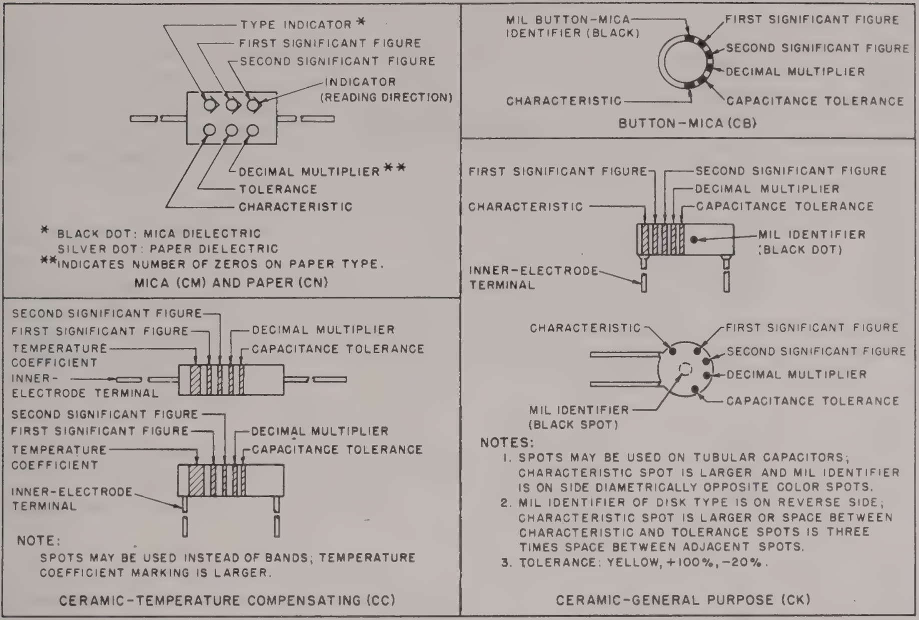
EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY; BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY; BLACK END; RED DOT OR BAND; SILVER END.

STD-R1

TM5091-29

Figure 286. MIL-STD resistor color code.

CAPACITOR COLOR CODE MARKING
(MIL-STD CAPACITORS)


TYPE INDICATOR *
FIRST SIGNIFICANT FIGURE
SECOND SIGNIFICANT FIGURE
INDICATOR (READING DIRECTION)
DECIMAL MULTIPLIER **
TOLERANCE
CHARACTERISTIC
MIL BUTTON-MICA IDENTIFIER (BLACK)
FIRST SIGNIFICANT FIGURE
SECOND SIGNIFICANT FIGURE
DECIMAL MULTIPLIER
CHARACTERISTIC
CAPACITANCE TOLERANCE
FIRST SIGNIFICANT FIGURE
SECOND SIGNIFICANT FIGURE
DECIMAL MULTIPLIER
CHARACTERISTIC
CAPACITANCE TOLERANCE
MIL IDENTIFIER (BLACK DOT)
INNER-ELECTRODE TERMINAL
SECOND SIGNIFICANT FIGURE
FIRST SIGNIFICANT FIGURE
DECIMAL MULTIPLIER
TEMPERATURE COEFFICIENT
CAPACITANCE TOLERANCE
INNER-ELECTRODE TERMINAL
SECOND SIGNIFICANT FIGURE
FIRST SIGNIFICANT FIGURE
DECIMAL MULTIPLIER
TEMPERATURE COEFFICIENT
CAPACITANCE TOLERANCE
INNER-ELECTRODE TERMINAL
CHARACTERISTIC
FIRST SIGNIFICANT FIGURE
SECOND SIGNIFICANT FIGURE
DECIMAL MULTIPLIER
CAPACITANCE TOLERANCE
MIL IDENTIFIER (BLACK SPOT)

* BLACK DOT: MICA DIELECTRIC
SILVER DOT: PAPER DIELECTRIC
**INDICATES NUMBER OF ZEROS ON PAPER TYPE.

MICA (CM) AND PAPER (CN)

BUTTON-MICA (CB)

NOTE:
SPOTS MAY BE USED INSTEAD OF BANDS; TEMPERATURE COEFFICIENT MARKING IS LARGER.

CERAMIC-TEMPERATURE COMPENSATING (CC)

NOTES:
1. SPOTS MAY BE USED ON TUBULAR CAPACITORS; CHARACTERISTIC SPOT IS LARGER AND MIL IDENTIFIER IS ON SIDE DIAMETRICALLY OPPOSITE COLOR SPOTS.
2. MIL IDENTIFIER OF DISK TYPE IS ON REVERSE SIDE; CHARACTERISTIC SPOT IS LARGER OR SPACE BETWEEN CHARACTERISTIC AND TOLERANCE SPOTS IS THREE TIMES SPACE BETWEEN ADJACENT SPOTS.
3. TOLERANCE: YELLOW, +100%, −20%.

CERAMIC-GENERAL PURPOSE (CK)

CAPACITOR COLOR CODE

COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC[1]				TOLERANCE [2]					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC		
											OVER 10UUF	10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		−30
RED	2	100	2	C	H		X	2		2	2		−80
ORANGE	3	1,000	3	D	J	D			30				−150
YELLOW	4	10,000	4	E	P								−220
GREEN	5		5	F	R						5	0.5	−330
BLUE	6		6		S								−470
PURPLE (VIOLET)	7		7		T	W							−750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	−330(±500)[3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-C1

TM5091-30

Figure 287. MIL-STD capacitor color code.

INDEX

	Paragraph	Page
A		
Accessories Case CY-1334/G, description	22	18
Additional Equipment required	32	24
Adjustment, installation procedures	55	43
Adjustment installation procedure for remote keying operation	56	57
Adjustments and checks, initial	54	40
Adjustments, preliminary	70	67
Alarm circuit	133	142
Alarm considerations, ppm system	105	104
Application, system	4	3
Arctic climates, operation in	77	71
Audio levels, system alignment	107	104
Audio terminations	131	138
Authority for demolition	221	267
B		
Blanking and insert circuit	42	28
	130	137
Blanking and insert, theory	116	115
C		
Cable connections	51	39
Cables, description	29	20
Channel pulses, modulation	114	114
Channels 1 and 2, operation	73	69
Channels 3 through 8, operation	74	71
Characteristics, technical	5	4
Chart, tube replacement	99	101
Checking resistance in grid circuit	156	180
Checking tubes	158	180
Checking, uncrating, and unpacking new equipment	48	32
Checklist, equipment performance	97	94
Checks and adjustments, initial	54	40
Chest CY-250/U, description	28	20
Circuit:		
Alarm	133	142
Blanking and insert	42	28
	116	115
	130	137
Delay line	126	128
Demultiplexing and demodulating	40	28
	111	111
	122	122
Modem demodulator	125	124
Modem modulator	129	132

INDEX (contd)

	Paragraph	*Page*
Modulating and multiplexing	41	28
	112	112
	127	129
Negative reshaping	120	117
Positive reshaping	121	121
Power supplies	43	29
Remote keying	45	30
	132	139
Reshaping	39	28
	110	110
Test and measurement	44	29
Circuits, miscellaneous, sectionalizing trouble to	95	93
Comparison of wave forms	160	181
Components:		
Minor	24	19
Table	8	6
Connections:		
Cable	51	39
Final	57	57
Considerations, remote keying	106	104
Control Monitor C–1151/TC:		
Controls	65	62
Description	21	18
Test equipment required	199	234
Theory	144	175
Trouble-shooting:		
Chart	201	236
Data	198	234
Procedure	200	235
Controls:		
Electrical equipment rack	62	59
Modem	60	58
Multiplexer subassembly	61	59
Oscilloscope	63	60
Power supply	66	65
Switch box	68	66
Test set	64	61
Video restorer	59	58
Voltage regulator	67	66
Correct use of ohmmeter low and high ranges	154	180
Crystals and rectifiers, special method of testing	161	182

D

Data:		
Packaging	6	5
Reference	215	253
Trouble shooting	147	177

INDEX (contd)

	Paragraph	*Page*
Definition of preventive maintenance	83	74
Delay line:		
Circuit	126	128
Description	15	14
Test equipment required	178	201
Test procedure	179	201
Trouble-shooting chart	180	201
Trouble-shooting data	177	201
Demodulating and demultiplexing circuit	40	28
	111	111
	122	122
Demolition, authority	221	267
Demultiplexing and demodulating circuit	40	28
	111	111
	122	122
Description:		
Accessories case CY–1334/G	22	18
Cables	29	20
Chest CY–250/U	28	20
Control Monitor C–1151/TC	21	18
Delay line	15	14
Electrical Connector Assembly J–535/G	27	19
Electrical Equipment Rack MT–1433/TCA–1	13	11
Electrical Standardized Components Case CY–1280/U	10	9
Multiplexer rack	11	10
Multiplexer Subassembly MX–1442/TC	16	15
Oscilloscope OS–25/G	19	15
Power Supply PP–691/G	23	19
Pulse Form Restorer TD–68/G	12	10
Remote Switching Control C–1509/TC	17	15
Switch Box SA–357/G	26	19
Telephone Modem MD–179/TC	14	12
Test rack	18	15
Test Set TS–762/TC	20	16
Voltage Regulator CN–236/G	25	19
Desert climates, operation in	79	72
Destruction, methods	222	267
Disassembly of equipment	220	266

E

Electrical Connector Assembly J–535/G, description	27	19
Electrical Equipment Rack MT–1433/TCA–1, description	13	11
Electrical power requirements	31	24
Electrical Standardized Components Case CY–1280/U, description	10	9
Equipment, disassembly	220	266
Equipment performance checklist	96	94
	97	95
Equipment required, additional	32	24

	Paragraph	Page
F		
Filament supply:		
Test equipment required	184	207
Tests	187	209
Theory	135	149
Trouble-shooting:		
Chart	186	208
Data	183	207
Procedure	185	207
Final connections and stopping procedure	57	57
Forms and records	2	1
H		
High voltages, precautions against	150	179
I		
Initial checks and adjustments	54	40
Insert and blanking circuit	42	28
	116	115
	130	137
Insertion of channel pulses into pulse train	128	130
Inspection, visual	91	79
Installation adjustment procedures	55	43
Installation adjustment procedure for remote keying operation	56	57
Installation, general	49	32
L		
Lubrication	87	78
M		
Measurement and test circuit	44	29
Measurements, voltage	149	178
Measuring resistance, precautions when	153	180
Methods of destruction	222	267
Minor components	24	19
Modem, telephone:		
Controls	60	58
Demodulator circuit	125	124
Demodulator tests	176	198
Description	14	12
Modulator circuit	129	132
Modulator tests	175	195
Test equipment required	171	193
Trouble-shooting:		
Chart	174	195
Data	170	193
Procedure	172	194

INDEX (contd)

	Paragraph	Page
Tube socket voltages and resistances	173	194
Modulating and multiplexing circuit	41	28
	127	129
Modulation of channel pulses	114	114
Modulation, pulse-position (ppm)	113	114
Mounting rack:		
Test procedure and test equipment required	182	203
Trouble-shooting data	181	203
Multiplexer Group AN/TCA–1:		
Component arrangement	9	9
Ppm-tdm system used	37	27
Tools and materials required	81	73
Multiplexer rack, description	11	10
Multiplexer set AN/TCC–13	102	103
Multiplexer Subassembly MX–1442/TC:		
Controls	61	59
Description	16	15
Multiplexing and modulating circuit	41	28
	112	112
	127	129

N

	Paragraph	Page
Negative reshaping circuit	120	117
New equipment, uncrating, unpacking and checking	48	32
Nomenclature assignments	7	6

O

	Paragraph	Page
Operation:		
Arctic climates	77	71
Channels 1 and 2	73	69
Channels 3 through 8	74	71
Desert climates	79	72
Order-wire channel	72	68
Time-division-multiplex (tdm)	115	114
Tropical climates	78	72
Order-wire channel, operation	72	68
Oscilloscope OS–25/G:		
Block diagram	137	150
Cathode-ray tube circuit	138	151
Controls	63	60
Description	19	15
Horizontal amplifier system	141	159
Power supply circuits	139	153
Test equipment required	193	215
Tests	197	219
Timing-pip-phase amplifier V28A	142*b*	167

INDEX (contd)

	Paragraph	*Page*
Trouble-shooting chart	196	218
Trouble-shooting data	192	215
Tube socket voltages and resistances	195	217
Vertical amplifier system	140	156
P		
Packaging data	6	5
Painting and rustproofing	89	78
Positive reshaping circuit	121	121
Power requirements, electrical	31	24
Power supplies:		
Circuit	43	29
Sectionalizing trouble	93	82
Theory	117	115
Power Supply PP–691/G:		
Controls	66	65
Description	23	19
Test equipment required	189	212
Theory	136	149
Trouble-shooting chart	191	215
Trouble-shooting data	188	212
Trouble-shooting procedure	190	213
Ppm, principles	36	26
Ppm system alarm considerations	105	104
Ppm-tdm system used in multiplexer group	37	27
Precautions:		
Against high voltages	149	178
When measuring resistance	153	180
Preliminary adjustments	70	67
Preventive maintenance:		
Definition	83	74
Forms, use	85	74
Performing	86	74
Techniques	84	74
Principles:		
Ppm	36	26
Tdm	35	25
Procedure:		
Installation	50	37
Installation adjustment	55	43
Starting	71	67
Stopping	75	71
Stopping and final connection	57	57
Test, final	218	253
Test, general	162	182
Trouble-shooting	146	177
Pulse Form Restorer Group AN/TRA–10	103	103

INDEX (contd)

	Paragraph	*Page*
Pulse Form Restorer TD–68/G, description	12	10
Pulse-position modulation (ppm)	113	114
Pulse train, insertion of channel pulses into	128	130
Purpose and use	3	2
R		
Radio-frequency link (Radio Set AN/TRC–29)	101	103
Receipt of used or reconditioned equipment, service upon	52	40
Reconditioned or used equipment, service upon receipt	52	40
Records and forms	2	1
Reference data	215	253
Refinishing	214	252
Remote keying:		
Circuit	45 132	30 139
Considerations	106	104
Operation, installation adjustment procedure	56	57
Remote Switching Control C–1509/TC	17	15
Removal of units and replacement parts	213	252
Repacking	220	266
Replacement of parts and removal of units	213	252
Requirements, electrical power	31	24
Reshaping circuit	39 110	28 110
Reshaping, wave form, principles	34	25
Running spares	30	24
Rustproofing and painting	89	78
S		
Sectionalizing trouble to:		
Components	92	80
Miscellaneous circuits	95	93
Power supplies	93	82
Test equipment	94	91
Service upon receipt of used or reconditioned equipment	52	40
Siting	47	32
Spares, running	30	24
Special method of testing crystals and rectifiers	161	182
Special tool not supplied	148	178
Special tools supplied	82	73
Starting procedure	71	67
Stopping procedure	57 75	57 71
Switch Box SA–357/G:		
Control	68	66
Description	26	19

INDEX (contd)

	Paragraph	*Page*
System alignment:		
Audio levels	107	104
Video levels	108	105
System application	4	3
T		
Table of components	8	6
Tdm-ppm system used in the multiplexer group	37	27
Tdm, principles	35	25
Technical characteristics	5	4
Terminations, audio	131	138
Test equipment required:		
Control monitor	199	234
Delay line	178	201
Filament supply	184	207
Final testing	216	253
Modem	171	193
Oscilloscope	193	215
Power supply	189	212
Test set	203	237
Video restorer	164	183
Voltage regulator	209	247
Test and measurement circuit	44	29
Test equipment:		
Sectionalizing trouble to	94	91
Theory of	118	115
Test procedure:		
Delay line	179	201
Final	218	253
General	162	182
Mounting rack	182	203
Video restorer	169	191
Test rack, description	18	15
Tests:		
Filament supply	187	209
Final	217	253
Modem demodulator	176	198
Modem modulator	175	195
Oscilloscope	197	219
Test set	207	242
Video restorer	168	191
Voltage regulator	212	248
Test set, audio:		
Adjustment of internal controls	206	238
Controls	64	61
Description	20	16

	Paragraph	*Page*
Test equipment required	203	237
Tests	207	242
Theory	143	169
Trouble-shooting chart	206	238
Trouble-shooting data	202	237
Voltage and resistance diagram	205	237
Time-division-multiplex operation (tdm)	115	114
Tool, not supplied, special	148	178
Tools and materials required for Multiplexer Group AN/TCA-1	81	73
Tropical climates, operation in	78	72
Trouble-shooting chart:		
Control monitor	201	236
Delay line	180	201
Filament supply	186	208
Oscilloscope	196	218
Power supply	191	215
Test set	206	238
Tube	98	96
Video restorer	167	189
Voltage regulator	211	248
Trouble-shooting data:		
Control monitor	198	234
Delay line	177	201
Filament supply	183	207
General	147	177
Mounting rack	181	203
Oscilloscope	192	215
Power supply	188	212
Test set	202	237
Video restorer	163	183
Voltage regulator	208	247
Trouble-shooting procedure:		
Control monitor	200	235
Filament supply	185	207
General	146	173
Power supply	190	213
Video restorer	165	183
Voltage regulator	210	247
Trouble shooting, scope	90	78
Trouble to a component, sectionalization	92	80
Tube checking	158	180
Tube replacement chart	99	101
Tube trouble-shooting charts	98	96

U

Unpacking, uncrating, and checking new equipment	48	32
Use and purpose	3	2

INDEX (contd)

	Paragraph	Page
Use of AN/TCA-1 with other equipment	104	103
Use of preventive maintenance forms	85	74
Used or reconditioned equipment, service upon receipt	52	40
V		
Ventilation system	46	31
Video restorer:		
Controls	59	58
Test equipment required	164	183
Test procedures	169	191
Tests	168	191
Trouble-shooting:		
Chart	167	189
Data	163	183
Procedure	165	183
Tube socket voltages and resistances	166	183
Visual inspection	91	79
Voltage measurements	149	178
Voltage regulator:		
Controls	67	66
Description	25	19
Test equipment required	209	247
Tests	212	248
Theory	134	145
Trouble-shooting:		
Chart	211	248
Data	208	247
Procedure	210	247
Voltmeter loading	151	179
W		
Waterproofing procedures and precautions	88	78
Wave form reshaping, principles	34	25
Wave forms, comparison	160	181
	159	181